RECENT ADVANCES in ENVIRONMENTAL SCIENCES and FINANCIAL DEVELOPMENT

Proceedings of the 2nd International Conference on Environment, Energy, Ecosystems and Development (EEEAD 2014)

Proceedings of the 2nd International Conference on Business Administration, Marketing and Economics (BAME 2014)

Athens, Greece
November 28-30, 2014

RECENT ADVANCES in ENVIRONMENTAL SCIENCES and FINANCIAL DEVELOPMENT

Proceedings of the 2nd International Conference on Environment, Energy, Ecosystems and Development (EEEAD 2014)

Proceedings of the 2nd International Conference on Business Administration, Marketing and Economics (BAME 2014)

Athens, Greece
November 28-30, 2014

All papers of the present volume were peer reviewed by no less than two independent reviewers. Acceptance was granted when both reviewers' recommendations were positive.

ISBN: 978-1-61804-255-2

RECENT ADVANCES in ENVIRONMENTAL SCIENCES and FINANCIAL DEVELOPMENT

Proceedings of the 2nd International Conference on Environment, Energy, Ecosystems and Development (EEEAD 2014)

Proceedings of the 2nd International Conference on Business Administration, Marketing and Economics (BAME 2014)

Athens, Greece
November 28-30, 2014

Organizing Committee

Editors:
Professor Charalampos Arapatsakos, Democritus University of Thrace, Greece
Professor Manijeh Razeghi, Northwestern University, USA
Professor Vassilis Gekas, Cyprus University of Technology, Cyprus

Program Committee:
Prof. Martin Bohner, Missouri University of Science and Technology, Rolla, Missouri, USA
Prof. Martin Schechter, University of California, Irvine, USA
Prof. Ivan G. Avramidi, New Mexico Tech, Socorro, New Mexico, USA
Prof. Michel Chipot, University of Zurich, Zurich, Switzerland
Prof. Xiaodong Yan, University of Connecticut, Connecticut USA
Prof. Ravi P. Agarwal, Texas A&M University - Kingsville, Kingsville, TX, USA
Prof. Yushun Wang, Nanjing Normal university, Nanjing, China
Prof. Detlev Buchholz, Universitaet Goettingen, Goettingen, Germany
Prof. Patricia J. Y. Wong, Nanyang Technological University, Singapore
Prof. Andrei Korobeinikov, Centre de Recerca Matematica, Barcelona, Spain
Prof. Jim Zhu, Western Michigan University, Kalamazoo, MI, USA
Prof. Ferhan M. Atici, Department of Mathematics, Western Kentucky University, USA
Prof. Gerd Teschke, Institute for Computational Mathematics in Science and Technology, Neubrandenburg, Berlin-Dahlem, Germany
Prof. Meirong Zhang, Tsinghua University, Beijing, China
Prof. Lucio Boccardo, Universita degli Studi di Roma "La Sapienza", Roma, Italy
Prof. Shanhe Wu, Longyan University, Longyan, Fujian, China
Prof. Natig M. Atakishiyev, National Autonomous University of Mexico, Mexico
Prof. Jianming Zhan, Hubei University for Nationalities, Enshi, Hubei Province, China
Prof. Narcisa C. Apreutesei, Technical University of Iasi, Iasi, Romania
Prof. Chun-Gang Zhu, Dalian University of Technology, Dalian, China
Prof. Abdelghani Bellouquid, University Cadi Ayyad, Morocco
Prof. Jinde Cao, Southeast University/ King Abdulaziz University, China
Prof. Josef Diblik, Brno University of Technology, Brno, Czech Republic
Prof. Jianqing Chen, Fujian Normal University, Fuzhou, Fujian, China
Prof. Naseer Shahzad, King Abdulaziz University, Jeddah, Saudi Arabia
Prof. Sining Zheng, Dalian University of Technology, Dalian, China
Prof. Leszek Gasinski, Uniwersytet Jagielloński, Krakowie, Poland
Prof. Satit Saejung, Khon Kaen University, Muang District, Khon Kaen, Thailand
Prof. Juan J. Trujillo, Universidad de La Laguna, La Laguna, Tenerife, Spain
Prof. Tiecheng Xia, Department of Mathematics, Shanghai University, China
Prof. Stevo Stevic, Mathematical Institute Serbian Academy of Sciences and Arts, Beogrand, Serbia
Prof. Lucas Jodar, Universitat Politecnica de Valencia, Valencia, Spain
Prof. Noemi Wolanski, Universidad de Buenos Aires, Buenos Aires, Argentina
Prof. Zhenya Yan, Chinese Academy of Sciences, Beijing, China
Prof. Juan Carlos Cortes Lopez, Universidad Politecnica de Valencia, Spain
Prof. Wei-Shih Du, National Kaohsiung Normal University, Kaohsiung City, Taiwan
Prof. Kailash C. Patidar, University of the Western Cape, Cape Town, South Africa
Prof. Hossein Jafari, University of Mazandaran, Babolsar, Iran
Prof. Abdel-Maksoud A Soliman, Suez Canal University, Egypt
Prof. Janusz Brzdek, Pedagogical University of Cracow, Cracow, Poland
Dr. Fasma Diele, Italian National Research Council (C.N.R.), Bari, Italy

Additional Reviewers

Eleazar Jimenez Serrano	Kyushu University, Japan
Xiang Bai	Huazhong University of Science and Technology, China
Jose Flores	The University of South Dakota, SD, USA
Genqi Xu	Tianjin University, China
Konstantin Volkov	Kingston University London, UK
João Bastos	Instituto Superior de Engenharia do Porto, Portugal
Abelha Antonio	Universidade do Minho, Portugal
Miguel Carriegos	Universidad de Leon, Spain
Tetsuya Yoshida	Hokkaido University, Japan
Bazil Taha Ahmed	Universidad Autonoma de Madrid, Spain
Moran Wang	Tsinghua University, China
Yamagishi Hiromitsu	Ehime University, Japan
Philippe Dondon	Institut polytechnique de Bordeaux, France
Manoj K. Jha	Morgan State University in Baltimore, USA
Frederic Kuznik	National Institute of Applied Sciences, Lyon, France
Minhui Yan	Shanghai Maritime University, China
Lesley Farmer	California State University Long Beach, CA, USA
Zhong-Jie Han	Tianjin University, China
Stavros Ponis	National Technical University of Athens, Greece
Ole Christian Boe	Norwegian Military Academy, Norway
Imre Rudas	Obuda University, Budapest, Hungary
Hessam Ghasemnejad	Kingston University London, UK
Matthias Buyle	Artesis Hogeschool Antwerpen, Belgium
Kazuhiko Natori	Toho University, Japan
Dmitrijs Serdjuks	Riga Technical University, Latvia
George Barreto	Pontificia Universidad Javeriana, Colombia
Kei Eguchi	Fukuoka Institute of Technology, Japan
James Vance	The University of Virginia's College at Wise, VA, USA
Shinji Osada	Gifu University School of Medicine, Japan
Francesco Rotondo	Polytechnic of Bari University, Italy
Valeri Mladenov	Technical University of Sofia, Bulgaria
M. Javed Khan	Tuskegee University, AL, USA
Andrey Dmitriev	Russian Academy of Sciences, Russia
Angel F. Tenorio	Universidad Pablo de Olavide, Spain
Jon Burley	Michigan State University, MI, USA
Deolinda Rasteiro	Coimbra Institute of Engineering, Portugal
Sorinel Oprisan	College of Charleston, CA, USA
Francesco Zirilli	Sapienza Universita di Roma, Italy
Alejandro Fuentes-Penna	Universidad Autónoma del Estado de Hidalgo, Mexico
Tetsuya Shimamura	Saitama University, Japan
Masaji Tanaka	Okayama University of Science, Japan
Takuya Yamano	Kanagawa University, Japan
Santoso Wibowo	CQ University, Australia
José Carlos Metrôlho	Instituto Politecnico de Castelo Branco, Portugal

Table of Contents

Smart Personal Assistant for Historical Tourism

Aleksey Varfolomeyev, Dmitry Korzun, Aleksandrs Ivanovs, and Oksana Petrina

Abstract— Mobile tourism is now an emerging domain area for the development of smart applications. They become personal mobile assistants for a user to receive recommendation services. This paper initiates a discussion on the development problem of smart services for such sub-area of mobile tourism as historical tourism. We employ the smart spaces approach. Application system architecture is proposed and supported with our vision on possible technology pool and computational methods for this kind of smart applications. Our solution constructs tourist's smart space where multiple sources of historical data are integrated and user context is kept. Historical points of interests (POI) are augmented with historical facts and relations. This semantic information inputs the computation of POI ranks, and the most relevant POIs are then provided personally to the user.

Keywords— e-Tourism, mobile services, recommender systems, smart spaces.

I. Introduction

NOWADAYS, much attention is paid to smart applications that act as intelligent assistants to users. Such applications can understand context, adapt to a situation, and deliver their services in a proactive style. A particular case is personal assistants or recommender systems, which support the users in their decision-making. Personal assistants become extremely popular in individual tourism, which now covers an essential share of the whole tourism market. For instance, a typical problem is trip planning. As a rule, selection of available options for a trip is subject to given time restrictions. The choice, however, is influenced by many other factors, and a smart personal assistant could effectively support this kind of decision-making.

Paper [1] provides an overview of intelligent recommender systems, which can be used to construct services for individual tourism; most of them are created as Web applications. In particular, mobile intelligent applications are emerging trend now, where the frontend operates on personal mobile devices of tourists (e.g., smartphones and tablets). Paper [2] considers mobile recommender systems and personal assistants that have been developed for tourists. Development of such applications is faced with a number of serious technological and algorithmic problems. Due to the low computational power of mobile devices and changeable network environment, the problems require specific solutions.

An interesting case is personal assistants for such a particular tourism domain as historical and cultural tourism [3]. In this case, the decision-making process requires much more information. Moreover, various links between 'points of interests' (POIs), historical knowledge, and cultural heritage assume utmost importance to the users, although this information, presumably, does not directly influence the decision-making process during a trip directly.

This paper considers the development of smart personal assistants for the mobile historical tourism. Such an application manipulates with semantic relations over data on historical objects and events, which are available in open knowledge bases (Linked Open Data Cloud – LOD Cloud), as well as in numerous digital archives that comprise marked up historical records. It is desirable that the relations are represented as links in a user-friendly style and recommended POIs are ranked in accordance with the personal needs of a user. Therefore, the application should provide recommendations to the user to visit relevant POIs.

We discuss practical and technological aspects of application development for mobile historical tourism. The intelligence primarily comes from semantic relations available in historical data.

The rest of the paper is organized as follows. Section II studies sources of historical information on POIs. Section III discusses the smart spaces approach to constructing services for mobile tourism. Section IV considers our computation method for personal ranking of historical POIs. Section V summarizes the discussion of this paper.

This research is financially supported by project # 1481 from the basic part of state research assignment # 2014/154 and by project # 2.2336.2014/K from the project part of state research assignment of the Ministry of Education and Science of the Russian Federation. The study is a part of project 14.574.21.0060 (RFMEFI57414X0060) of Federal Target Program "Research and development on priority directions of scientific-technological complex of Russia for 2014-2020". The article was published with financial support from the Strategic Development Program of Petrozavodsk State University

Aleksey Varfolomeyev is with the Department of Probability Theory and Data Analysis, Petrozavodsk State University, Petrozavodsk, Russia (phone: +7-953-536-0268; fax: +7-814-271-1000; e-mail: avarf@petrsu.ru).

Dmitry Korzun is with the Department of Computer Science, Petrozavodsk State University, Russia (e-mail: dkorzun@cs.karelia.ru) and with Helsinki Institute for Information Technology (HIIT) and Department of Computer Science and Engineering (CSE), Aalto University, Finland (e-mail: dkorzun@hiit.fi).

Aleksandrs Ivanovs is with the History Department, University of Daugavpils, Daugavpils, Latvia and with the Institute of Regional Studies (REGI), Rezekne Higher Education Institution, Rezekne, Latvia (e-mail: aleksandrs.ivanovs@du.lv).

Oksana Petrina is with the Faculty of Mathematics, Petrozavodsk State University, Petrozavodsk, Russia (e-mail: petrina@cs.karelia.ru).

II. Local Historical Data: Prospects for Semantic Description

In recent research papers, cultural tourism (or cultural heritage tourism) is considered as a specific form of tourism. Typically, historical tourism is not detached from more general concept of cultural heritage tourism. Only few exceptions can be mentioned there. For example, Smith [3] considers the historical tourism as one of the five major types of tourism. In our opinion, it is obvious that cultural heritage embraces both historical and quite modern objects and phenomena (e.g., music festivals), as well as different ethnographic phenomena, such as rituals, dances, local dishes, etc. On the other hand, a 'historical tourist' is focused on the objects (POIs) that are associated, first and foremost, with historical events and persons. It means that local historical information is of utmost importance for such a tourist, and this information should be detached from diverse cultural data. Moreover, this information should be reliable, precise, and exhaustive. It should be noted that historical information is represented in historical records, which predetermine trustworthy and value of the information. According to Nora [14], along with historical POIs, written documents that recall the past are considered so-called 'sites of memory'. Therefore, the POIs along with the written historical records create specific historical domains for the tourists.

For the semantic linkage of historical POIs with other historical objects (persons, historical facts as such, etc.), it is necessary to generate a historical knowledge base, i.e., semantically interconnected information about diverse historical objects. Currently, all public knowledge bases are represented in LOD Cloud by means of the Semantic Web technologies – RDF or OWL. In the last decade, there have been made numerous attempts to create historical ontologies, see [6], [7], [8], [9], [10]. For instance, ontology CIDOC CRM [11] is specially designed for the description of museum artifacts. It can be effectively employed to arrange knowledge about historical persons and events. Although this ontology is not sufficient to reflect adequately information provided by historical documents, it is widely used in semantic publishing of historical records (see, e.g., [4], [5]). Considerable historical data arrays have been accumulated in regional databases, such as 'Latgales Dati' [15]; unfortunately, this information is not represented in RDF or OWL format. The need to link semantically local information semantically within definite historical semantic networks for the purposes of historical research is quite evident. Nevertheless, only some few attempts to design such semantic networks can be mentioned there [28]. Thus, despite obvious needs, up to now specialized historical knowledge bases are not available on the Semantic Web.

Historical information is also presented in universal knowledge bases, such as Dbpedia, Freebase, and YAGO. Dbpedia (dbpedia.org) is created by means of automatic transmission of information from the Wikipedia pages to a semantic network. To be precise, the transmission is possible, if this information is provided in a structured form only: categories related with a Wikipedia page, references to other pages as well as to external resources, facts presented in 'infoboxes', i.e., fragments of the pages, which provide data that is structured according to a certain pattern.

Freebase [18] is also based on the Wikipedia pages. In contrast to Dbpedia, it contains much more information, since the network community can feed in additional data manually. The entities in Freebase are also divided into categories; the system of these categories is to be created manually – it cannot be copied from Wikipedia. In Freebase, the number of categories is significantly less than in Dbpedia; they are not divided into subcategories and can be included in super categories (the so-called domains).

YAGO [29] assumes an intermediate position between the two knowledge bases mentioned above. On the one hand, like Dbpedia, YAGO is based on the entities and categories (as well as on the relations between them) that are automatically extracted from Wikipedia. On the other hand, YAGO supplements the spontaneously created (and therefore, to a certain extent, ill-conceived) Wikipedia's taxonomy with the categories, which are established automatically using the semantic WordNet dictionary. These categories are rather similar to Freebase categories.

Many historical POIs, as well as other historical objects (persons, events, etc.) related to the POIs are mentioned in Wikipedia. Therefore, the information about these historical objects is reflected, to some extent, in the above-mentioned knowledge bases.

Finally, semantically arranged historical information can be extracted from XML-publications of historical documents [13], since such markup schemes as TEI (www.tei-c.org) and, especially, CEI (www.cei.lmu.de) make it possible to mark up diverse historical objects in the texts of the documents. For this purpose, the CEI tags <persName>, <roleName>, <issuer>, and <addressee>, as well as the universal tag <name> in combination with the attribute 'type', can be used. To create a knowledge base on the basis of XML-markup, a program that either directly translates XML into OWL, or generates statements in Attempto Controlled English (ACE) from XML-texts [12] should be written.

The following example shows how the rules for converting XML into ACE can be established. A fragment of a medieval charter that dates back to the 13th century has been marked up according to the CEI scheme in order to single out historical objects:

```
<charter id="Charter6">
……
<issuer reg="Ch6_p1">
<roleName reg="archbishop">Metropolitan's</roleName> of
<name type="city">Riga</name></issuer> benediction…
……
</charter>
```

In this fragment, the attribute 'reg' (regular) serves two purposes. The first purpose is to set identifiers for unknown objects, whose names are not mentioned in the text of a document (for instance, the tag <issuer>). The second purpose is to present generally accepted (standard) forms of names for well-known objects (for instance, ‘archbishop’ – the actual position/ role of the person, who is mentioned in the charter as a ‘metropolitan’).

Based on this marked up fragment, the following sentences in ACE can be formulated:

Charter6 is a charter. Ch6_p1 sends Charter6. Charter6 mentions Ch6_p1.
Every archbishop is a person. Ch6_p1 is an archbishop. Charter6 mentions an archbishop.
Riga is a city. Ch6_p1 lives in Riga. Charter6 mentions Riga.

The program, which generates ACE-statements from XML-markup, should apply the following rules:

<charter id=”X”> => X is a charter.
<charter id=”X”>…<issuer reg=”Y”>…</issuer>…</charter> => Y sends X. X mentions Y.
<roleName reg=”role_x”> => Every role_x is a person.
<issuer reg=”Y”>…<roleName reg=”role_x”>…</roleName>…</issuer> => Y is a role_x. (Следовательно, Y is a person).
<charter id=”X”>…<roleName reg=”role_x”>…</roleName>…</charter> => X mentions a role_x.
<name type=”city”>Z</name> => Z is a city.
<issuer reg=”Y”>…<name type=”city”>Z</name>…</issuer> => Y lives in Z.
<charter id=”X”>…<name type=”city”>Z</name>…</charter> => X mentions Z.

Automatically generated ACE-statements can be converted to OWL using the Attempto Parser Engine.

III. Architecture and Technologies

A. Application Scenario

Let us consider the application that acts as a smart personal assistant for historical tourist. The basic application scenario can be as follows. The user chooses the initial (i.e. preferable) POI. The application should find for this POI the entity that 1) is described in available knowledge bases, 2) reveals interconnections between the entity and other POIs, as well as facts about the entity, which are of interest for the user. As a result, a semantic network focused on the initial POI is being produced. Finally, the semantic network is displayed to the user in an adapted form according to the user’s preferences.

There are many options to implement each of the steps within this scenario. Thus, the application can choose a definite POI taking into consideration the proximity of the present locality of a tourist to the coordinates of POIs that are represented in the available knowledge bases. In this case, the choice is made automatically; if it is necessary, ranking the options (several POIs) is also possible. It should be noted that the application determines POIs in accordance with their geographic coordinates only. If these coordinates are not precise or the locality is not provided at all, the application will not determine the POIs. Another option is a semi-automatic mode of choosing preferable POIs: the user inputs either the name of an object, or any characteristic features of a definite POI, or geographic coordinates (points) on a map. Both variants – proactive searching for potentially interesting objects and implementation of a user’s query – should be implemented to achieve desirable flexibility of the application.

The scope of the knowledge bases available to the application should be defined beforehand, since any database has its own specific features, hence, within different knowledge bases algorithms of data retrieving and processing differ substantially. At present, two alternative types of knowledge bases might be used: on the one hand, the universal knowledge bases such as Dbpedia, Freebase, and YAGO, on the other hand, knowledge bases in the form of OWL-files that are generated on the basis of XML-publications of historical records. As a rule, tourist objects that are represented in the universal knowledge bases have precise geographic coordinates. Moreover, these objects are characterized by numerous categories. It means that the universal knowledge bases allow implementing proactive search for the POIs proximate to the locality of a user as well as ranging the POIs in accordance with their relevance to the user’s preferences. The preferences can be also determined by a set of categories, which define the POIs that the user has already chosen. Thus, the data provided by the universal knowledge bases make it possible to implement all stages within the work scenario of the Smart Personal Assistant; nevertheless, special algorithms are needed to compare the sets of categories.

On the contrary, OWL-files generated from the XML-publications of historical records do not provide geographic coordinates of the POIs, as well as identifiers and categories linked to the identifiers. Instead of this, the knowledge base determines names of the objects that are mentioned in documents. It means that such knowledge bases cannot be used to choose an initial POI. These knowledge bases might be employed to reveal interconnections as well as facts about the initial POI. The searching algorithms should be implemented employing record linkage methods worked out for the purposes of searching for similar objects that, possibly, bear different names in different historical records.

Let us describe more formally the case of universal knowledge bases. The basic personal data the user u specifies for the service is the initial POI s_0 and tourist's context c_u. Let S be a set of all the POIs the service has found in universal knowledge bases. We assume $s_0 \in S$.

In general, the tourist's context encompasses all personal information that can be related to POIs. In particular, we consider the POIs that the tourist has already visited, i.e., $c_u \subset S$. Additionally, we allow attributes for each $s \in c_u$, e.g., the date of a visit and time spent.

Let us now focus on the POIs ranking service. It produces the following information for the tourist u. Given s_0 and c_u, provide ranks r_s for $s \in S$. This quantitative information then can be used for the effective visualization (service delivery) of the derived POI-related knowledge to the user. For instance, the user is provided with a rank-sorted list of POIs where the order reflects the relevance of each POI to s_0 in respect to the user’s personal interests. Another option is to visualize all high-ranked POIs on a map.

B. *Smart Spaces*

In the broad sense, smart spaces form a paradigm for programming computing environments, which are networked and embedded into human surroundings, see [19], [20] and references therein. Such an environment, first, is equipped with variety of devices (sensors, data processors, consumer electronics, personal mobile devices, multimodal systems, etc.). Second, the environment has an access to the Internet and its pool of services and resources. Without the loss of generality, smart space participants are people (end-users), devices, services, and data sources. Any smart space supports cooperation of all its participants in order to provide its users with convenience, safety, and comfort. The environment is made 'smart' to handle the growth of the number of participants and the amount of information to be processed.

The required cooperation is based on the blackboard model: a shared view of resources is established in the environment. Software part of a smart environment includes two sides: 'agents' and information 'hub', see Fig.1. The hub is a heart of its smart space, keeping shared information content for the required cooperation. Each agent is an autonomous knowledge processor (KP), which is a software module running on some device. Participants are represented by their agents. Users participate using their personal devices (e.g., smartphone) and multimodal systems (e.g., interactive media interfaces). Some agents represent 'things' from the physical world (i.e., acting as a smart object from Internet of Things). Similarly, some agents represent entities of the information world (e.g., web services and databases).

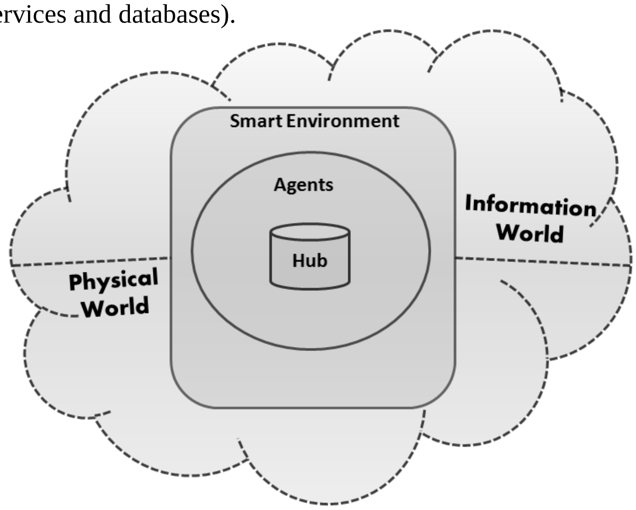


Fig. 1. Smart Space

Each KP produces its share of information and makes it available to others via the hub. Similarly, KP consumes information of its own interest from the hub. In the narrow sense, a smart space is a multi-agent knowledge base, which keeps shared content (generated cooperatively by KPs) and provides its participants with networked means to access and process this content. Activity of all KPs within their smart space creates fusion of the physical and information worlds when the smart space selectively encompasses all related information from both worlds.

Shared content can be represented using well-known technologies of the Semantic Web. The hub becomes a semantic information broker (SIB), which maintains an RDF triplestore. The latter can be considered a set of triples or, on higher semantic level an RDF graph consisting of all triples. Typical access primitives for KPs are "insert", "update", and "remove", parameterized with RDF subgraphs. These primitives can be further empowered with semantic search queries, e.g., based on SPARQL. An additional powerful operation is subscription, which also supports search queries. A particular technological platform for creating such smart spaces is Smart-M3 [21].

The use of smart spaces for e-Tourism services is a new research area, see [22] - [25]. In contrast to typical smart spaces deployment, which is localized in a physical spatial-restricted place (e.g., room, building, city square), a smart space for e-Tourism services is essentially mobile. One should think that such a smart space 'accompanies' its tourists. Most of devices of the computing environment are located far from the user side, e.g., on remote Internet servers, as it happens in the traditional approach of web services. Each user accesses the smart space using her personal mobile device.

Advantages (in particular in comparison with the traditional web-based approach):

- interoperability: many heterogeneous elements can participate and interact each with other;
- multiple data sources (historical databases): a virtual corpus of historical data is formed in the smart space (hub property);
- service personalization: the corpus of historical data is searched based on user-aware information;
- proactive service delivery: the corpus provide information on what service is needed, when, and to whom;
- adding other kinds of information to the semantics of: 1) historical data corpus, 2) personalization part of the collected knowledge.

C. *System Architecture*

Our architecture involves the following classes of KPs.

- Data source KPs: provide the smart space with historical data (POIs from Dbpedia and other sources).
- Client KPs: allow the user to participate in the smart space receiving its services.
- Personalizer KP: constructs a personalized structure of POIs.
- Ranking KP: makes ranking based on a given personalized structure of POIs.

ISBN: 978-1-61804-255-2

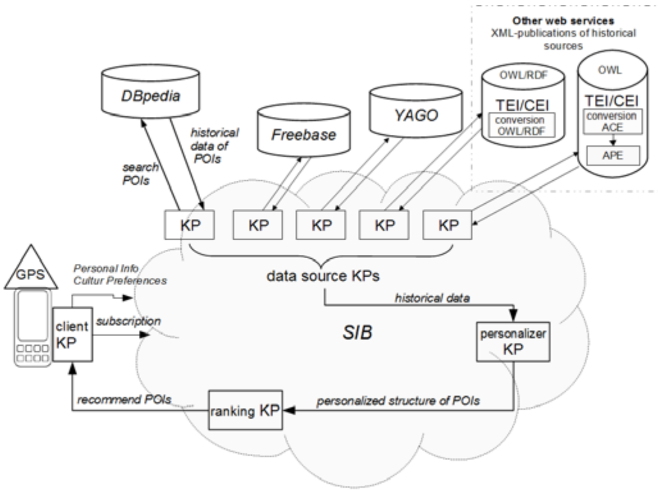


Fig. 2. System architecture

The basic steps for construction of the POI ranking service are as follows. First, data source KPs are associated with historical data bases. The KPs form the smart space content as a representation of P with semantic relations between POIs. Such relations can be established through various historical objects (not only through POI). Examples are

- s_1 and s_2 were build by the same architect;
- s_1, s_2, and s_3 follows the same style the baroque.

This POI-based content is common for all tourists. The second step is personalization.

Whenever the client KP of user u provides user's data (s_0 and c_u) the personalizer KP constructs a personalized POI structure from the common content. The personalized structure has a form of a directed graph, where nodes are partitioned into three classes: s_0 (the initial POI), c_u (visited POIs), and $S \setminus (s_0 \cup c_u)$ (candidate POIs).

The final step of service construction is ranking over the personalized POI structure. Each candidate POI becomes assigned with a rank value. The client KP can use these values for representation of recommended POIs to the user.

IV. Computational Methods

Let us consider the problem of ranking the available POIs by the level of proximity to the tourist's context c_u. For simplicity, it can be assumed that each POI only has information about categories: for each POI $s \in S$ and for each available universal knowledge base K_i, there exists the set of categories T_s^i (if s is not described in K_i then $T_s^i = \varnothing$). Let us take one of the known distances between the sets $\rho(A,B)$ [26, 27]. Then the distance between c_u and s in the knowledge base K_i might be determined as a minimal (or average) distance between all of the sets of categories T_t^i for the POIs $t \in c_u$, and the set T_s^i, e.g.,

$$\rho^i(c_u, s) = \min_{t \in c_u} \rho\left(T_t^i, T_s^i\right)$$

The aggregated distance $\rho(c_u, s)$ between POI $s \in S$ and the tourist's context c_u can be determined as the minimal (or average) distance within the set of all distances $\rho^i(c_u, s)$. In accordance with the value $\rho(c_u, s)$ the POIs $s \notin s_0 \cup c_u$ can be ranked.

To implement this approach it is necessary to make distances $\rho^i(c_u, s)$ comparable to each other. In practice, the systems of categories can differ essentially within different knowledge bases (e.g., in Dbpedia, Freebase, and YAGO). Thus, in different knowledge bases, there will be systematic differences in the values of distances between the sets of categories. To settle the differences we propose to use the probabilistic approach determining distances between the subsets of a finite set [26].

Formally, given $U = \{u_1, u_2, \ldots, u_n\}$, let X and Y be two random subsets of U. We represent the subsets X and Y as two binary vectors x and y, which are constructed as follows: $x_i = 1$ if only $u_i \in X$, otherwise $x_i = 0$ (similarly for y and Y). We denote $p_i, i = 1, \ldots, n$ the probability of u_i appearance in the subset. Then we can carry out a random experiment, which consists of n independent tests. Each test can have one of the four possible outcomes $A^i{}_{\alpha\beta} = \{x_i = \alpha, y_i = \beta\}$, where $\alpha, \beta \in \{0,1\}$, i is the number of a test. Let $I(A)$ is an indicator of a random event A; a, b, c, d are overall quantities of the outcomes $A_{11}^i, A_{10}^i, A_{01}^i, A_{00}^i$ correspondingly. Note that $a = |X \cap Y|$, $b = |X \setminus Y|$, $c = |Y \setminus X|$, $d = |U \setminus (X \cup Y)|$, where $|X|$ is the quantity of elements in X. Then $I(A_{11}^i) + I(A_{10}^i) + I(A_{01}^i) + I(A_{00}^i) = 1$, $a + b + c + d = n.$

The set of random events can be introduced as follows:

$$B = \left\{ \left(A_{11}^1, A_{10}^1, \ldots, A_{00}^n\right) : \sum_{i=1}^n I\left(A_{11}^i\right) = a, \sum_{i=1}^n I\left(A_{10}^i\right) = b, \sum_{i=1}^n I\left(A_{01}^i\right) = c, \sum_{i=1}^n I\left(A_{00}^i\right) = d \right\}.$$

Usually (see, e.g., [27]) different distances between the sets are described as functions of a, b, c, d, i.e., $\rho(X,Y) = h(a,b,c,d)$.

Then the function of distribution of the random value $\rho(X,Y)$ could be described as follows:

$$F(t) = P(\rho(X,Y) < t) =$$
$$= \sum_{(a,b,c,d)\in C} \sum_{\left(A_{11}^{1},\ldots,A_{00}^{n}\right)\in B} \prod_{i=1}^{n} p_i^{2I\left(A_{11}^{i}\right)} \times \quad (1)$$
$$\times (1-p_i)^{2I\left(A_{00}^{i}\right)} \left(p_i(1-p_i)\right)^{I\left(A_{01}^{i}\right)+I\left(A_{10}^{i}\right)}$$

where

$$C = \{\ (a,b,c,d) \in Z^4 : a,b,c,d \geq 0,$$
$$a+b+c+d = n, h(a,b,c,d) < t\ \}.$$

At this point, the value $F(\rho)$ can be taken as a new (probabilistic) ‘distance’ between the subsets X and Y, where ρ is the previously determined value of distance between X and Y. This probabilistic distance assumes values between 0 and 1. If the value of the probabilistic distance is high (close to 1), then it means that there are not numerous pairs of the sets X and Y, that have a distance value between them that exceeds or is equal to ρ. Accordingly, if the value is low (close to 0), then the value less than ρ can seldom be stated.

This approach is quite applicable to the case, if in knowledge bases in order to characterize two POIs two sets of categories are used instead of subsets. Thus, the values of distance provided by different knowledge bases become comparable. The probabilities p_i can be estimated taking into consideration frequency of occurrence of a definite category. However, to apply the formula (1), the categories should be independent (in probabilistic sense), i.e. affiliation of an object with a certain category should not alter the probability of belonging of the same object to other categories. As often as not, in the existing knowledge bases, this condition is not observed. Probabilistic distribution of the distance $\rho(X,Y)$ can be achieved for mutually dependent categories also. However, in each definite case of mutual dependence of categories, special distribution functions should be used instead of (1).

Besides the possibility to compare the distances between the sets of categories, the probabilistic distance provides one more advantage: it provides an opportunity to evaluate the value of distance in the terms ‘long’/‘short’ before the whole set of the distances $\rho(c_u, s)$ has been obtained. In the mobile environments, this extra opportunity is very useful, since it reduces the amount of computation by means of ranging POIs in accordance with the preferences and interests of a user.

V. Conclusion

This paper discussed development recommendation services for historical tourism based on knowledge bases available in the Internet. In our application scenario, such a service can be constructed based on ranking for available POIs using semantic network over these POIs with personalization. Well-known mathematical methods can be then used for these computations. We also expect that the considered smart spaces approach is very prominent for development of such applications. First, the data representation and processing benefit from advanced technologies of Semantic web. Second, interaction between the user and services become more intelligent than in traditional web services.

References

[1] J. Borràs, A. Moreno, and A. Valls, “Intelligent tourism recommender systems: a survey,” *Expert Systems with Applications*, vol. 41, pp. 7370–7389, Nov. 2014.

[2] D. Gavalas, C. Konstantopoulos, K. Mastakas, and G. Pantziou, “Mobile recommender systems in tourism,” *Journal of Network and Computer Applications*, vol. 39, pp. 319–333, Mar. 2014.

[3] V. S. Smith (ed.), *Hosts and Guests: The Anthropology of Tourism*, 2nd ed. University of Pennsylvania Press, Philadelphia, 1989.

[4] E. Ahonen and E. Hyvönen, “Publishing historical texts on the Semantic Web – a case study,” in *Proc. of the Third IEEE International Conf. on Semantic Computing (ICSC 2009)*, Berkeley, 2009, pp. 167–173.

[5] N. Ide and D. Woolner, “Historical ontologies,” in *Words and Intelligence II,. Essays in Honor of Yorick Wilks,* K. Ahmad, Chr. Brewster, M. Stevenson, Eds., Springer, 2007, pp. 137–152.

[6] M. Kalus. (2007, Dec.) Semantic Networks and Historical Knowledge Management: Introducing New Methods of Computer-based Research. *Journal of the Association for History and Computing.* [Online]. vol. 10(3). Available: http://hdl.handle.net/2027/spo.3310410.0010.301

[7] A. Meroño-Peñuela, A. Ashkpour, L. Rietveld, R. Hoekstra, and S. Schlobach, “Linked humanities data: the next frontier? A case-study in historical census data,” in *Proc. of the 2nd International Workshop on Linked Science 2012 (LISC2012), ISWC 2012*, Boston, 2012. Available: http://ceur-ws.org/Vol-951/paper3.pdf

[8] V. Mirzaee, L. Iverson, and B. Hamidzadeh, “Computational representation of semantics in historical documents,” in *Proc. of the XVI International Conf. of the Association for History and Computing*, Amsterdam, 2005, pp. 199–206.

[9] M. Pasin and J. Bradley. (2013, July) Factoid-based prosopography and computer ontologies: towards an integrated approach. *Literary and Linguistics Computing.* First published online. Available: doi: 10.1093/llc/fqt037

[10] B. Robertson. (2009). Exploring historical RDF with Heml. *Digital Humanities Quarterly*. 3(1). Available: http://www.digitalhumanities.org/dhq/vol/3/1/000026.html

[11] M. Doerr and A. Kritsotaki. (2006). Documenting events in metadata. *The 7th International Symp. on Virtual Reality, Archaeology and Cultural Heritage VAST*. [Online]. Available: http://www.cidoc-crm.org/docs/fin-paper_cyprus.pdf

[12] A. Varfolomeyev and A. Ivanovs, “Representation of historical sources on the Semantic Web by means of Attempto Controlled English,” in *Knowledge Engineering and the Semantic Web, Proc. 4th International Conf., KESW 2013, CCIS 394*, Springer-Verlag, 2013, pp. 177–190.

[13] A. Ivanovs and A. Varfolomeyev, “Editing and exploratory analysis of medieval documents by means of XML technologies. The case of the documentary source complex Moscowitica–Ruthenica,” in *Proc. of the XVI International Conf. of the Association for History and Computing*, Amsterdam, 2005, pp. 155–160.

[14] H. Soms and A. Ivanovs, “Historical peculiarities of Eastern Latvia (Latgale): their origin and investigation,” *Humanities and Social Sciences Latvia*, n. 3, pp. 5–21, 2002.

[15] Latgales Dati, Available: http://latgalesdati.du.lv/

[16] Attempto Project, Available: http://attempto.ifi.uzh.ch

[17] P. Nora, “Between memory and history,” *Representations*, vol. 26 (Spring), pp. 7-25, 1989.

[18] K. Bollacker, C. Evans, P. Paritosh, T. Sturge, and J. Taylor, “Freebase: a collaboratively created graph database for structuring human knowledge,” in *Proc. of the 2008 ACM SIGMOD International Conf. on Management of Data*, Vancouver, 2008, pp. 1247–1250.

[19] S. Balandin and H. Waris, “Key properties in the development of smart spaces,” in *Proc. 5th Int'l Conf. Universal Access in Human-Computer*

Interaction (UAHCI '09). Part II: Intelligent and Ubiquitous Interaction Environments, LNCS 5615, Springer-Verlag, 2009, pp. 3-12.

[20] D.G. Korzun, “Service formalism and architectural abstractions for smart space applications,” in *Central & Eastern European Software Engineering Conference in Russia (CEE-SEC(R) 2014)*, Moscow, 2014.

[21] J. Honkola, H. Laine, R. Brown, and O. Tyrkko, “Smart-M3 information sharing platform,” in *Proc. IEEE Symp. Computers and Communications (ISCC’10). IEEE Computer Society*, Jun. 2010, pp. 1041-1046.

[22] A. Smirnov, A. Kashevnik, S. Balandin, and S. Laizane, “Intelligent mobile tourist guide,” in *Proc. 13th Int’l Conf. Next Generation Wired/Wireless Networking and 6th Conf. on Internet of Things and Smart Spaces (NEW2AN/ruSMART 2013). LNCS 8121*, S. Balandin, S. Andreev, and Y. Koucheryavy, Eds. Springer-Verlag, Aug. 2013, pp. 94-106.

[23] A. Smirnov, A. Kashevnik, A. Ponomarev, N. Shilov, M. Schekotov, and N. Teslya, “Recommendation system for tourist attraction information service,” in *Proc. 14th Conf. of Open Innovations Association FRUCT*, S. Balandin and U. Trifonova, Eds. SUAI, Nov. 2013, pp.148-155.

[24] D. Korzun, I. Galov, A. Kashevnik, and S. Balandin, “Virtual shared workspace for smart spaces and M3-based case study,” in *Proc. 15th Conf. of Open Innovations Association FRUCT*, S. Balandin and U. Trifonova, Eds. ITMO Univeristy, Apr. 2014, pp. 60-68.

[25] K. A. Kulakov and A. I. Shabaev, “An approach to creation of smart space-based trip planning service,” in *Proc. 16th Conf. of Open Innovations Association FRUCT*, Oct. 2014.

[26] A. A. Varfolomeyev, P. V. Kirikov, A. A. Rogov, “Probabilistic approach to distance comparison between subsets of Finite Set,” *Proc. of Petrozavodsk State University. Natural & Engineering Sciences.* vol. 8(113), Dec. 2010, pp. 83-88. (In Russian)

[27] M.J. Warrens, “Similarity coefficients for binary data,” Ph.D. dissertation, Leiden, 2008

[28] A. Varfolomeyev, H. Soms, and A. Ivanovs, “Knowledge-based information systems in research of regional history,” in *Digital Humanities 2008.* Oulu, 2008, p.210-211.

[29] E. Demidova, I. Oelze, and W. Nejdl, “Aligning Freebase with the YAGO ontology,” in *Proc. 22nd ACM Int. Conf. on Information and Knowledge Management, CIKM 2013*, ACM, New York, 2013, pp.579-588.

Modeling of solar irradiation absorbed by a photovoltaic panel with low concentration

Ionel Laurentiu Alboteanu, Cornelia Aida Bulucea, Sonia Degeratu

Abstract— Solar irradiation is one of the important parameters that should be taken into consideration for the design and utilization of a photovoltaic system. This paper presents several mathematical models for the solar irradiation assessment. The starting point is represented by the mathematical model of the extraterrestrial irradiation, getting finally the model of the solar irradiation absorbed by a low concentration photovoltaic panel. The models particularized for a certain location are verified by numerical simulation.

Keywords— low concentrating photovoltaic system, mathematical models, photovoltaic panel, solar irradiation.

I. Introduction

Over the last decades, because of the pollution and awareness of limited resources of fossil fuels, the renewable sources of energy production gained increasing confidence as appropriate solution for humankind.

Within the south region of Romania, due to the high solar potential there have been developed numerous photovoltaic stations. Still, one could note that these solar plants take a considerable part of agricultural land.

This paper is the starting work of a study that aims to address meaningfully the issues of increasing efficiency of the photovoltaic systems by utilization of solar radiation concentrator elements, as well as of reducing of costly photovoltaic surface.

Analysis of a conversion system of solar energy to electric energy is based on an accurate assessment of solar radiation in the location given. Hence, it should be known aspects of solar radiation properties, as well as aspects regarding astronomical data.

Regarding the calculation of solar irradiation absorbed by low concentration photovoltaic panel (LCPV), in literature [4], [5], [8], [12], there are approached these aspects, but with values and particularities for certain locations submitted to study.

This work was partially supported by the grant number 29C/2014, awarded in the internal grant competition of the University of Craiova.

I. L. Alboteanu is with the University of Craiova, Faculty of Electrical Engineering, Department of Electromechanics, Environment and Industrial Informatics, Romania, 200440 Craiova, Tel.0251 435 724, Fax. 0251 435 255; e-mail: lalboteanu@em.ucv.ro.

C. A. Bulucea is with the University of Craiova, Faculty of Electrical Engineering, Department of Electromechanics, Environment and Industrial Informatics, Romania, 200440 Craiova, Tel.0251 435 724, Fax. 0251 435 255; e-mail: abulucea@em.ucv.ro.

S. Degeratu is with University of Craiova, Faculty of Electrical Engineering, Department of Electromechanics, Environment and Industrial Informatics, Romania, 200440 Craiova, Tel.0251 435 724, Fax. 0251 435 255; e-mail: sdegeratu@em.ucv.ro.

II. Modeling and simulation of solar irradiation

A. *Extraterrestrial irradiation*

In order to get to the mathematical model of solar irradiation absorbed by a photovoltaic panel provided with a low radiation concentration system one could start from the mathematical model of extraterrestrial irradiation.

Although in some models from the literature the extraterrestrial solar radiation is considered constant [14], the model of extraterrestrial solar radiation for a certain location could be expressed by the relation below:

$$G_0 = \frac{24}{\pi} \cdot S \cdot \left[1 + 0{,}33 \cdot \cos\left(\frac{2\pi \cdot n}{365}\right)\right] \cdot \cdot \left(\cos\varphi \cdot \cos\delta \cdot \sin\omega_s + \omega_s \cdot \sin\varphi \cdot \sin\delta\right) \quad [\mathrm{W/m^2}] \quad (1)$$

where:
S is the solar constant ;
n is the days' number of the year;
φ is the altitude of ten location considered;
δ represents declination of the Earth; and
ω_s is the solar angle.

Particularizing the mathematical relationship (1) for the Romanian city of Craiova as location (φ=44,3^o) it had resulted the diagram of extraterrestrial irradiation evolution during the year (see Fig.1).

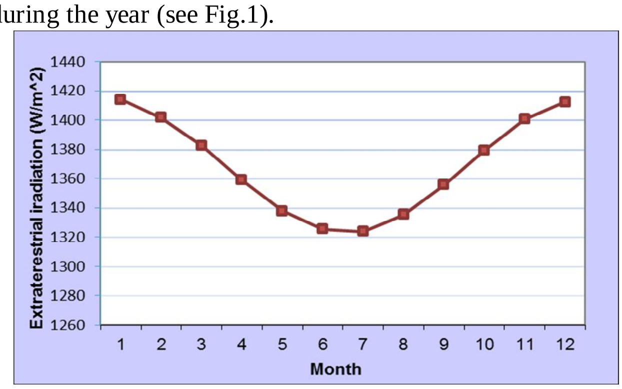


Fig. 1 Chart of annually extraterrestrial irradiation for Craiova location

As can be seen in Figure 1, the extraterrestrial solar irradiation particularized for a certain location is not constant over the duration of an entire year.

Influence of atmosphere

The air mass *m* is characterizing the path travelled by the solar ray through the atmosphere to the sea level. One could note that m=0 for the extraterrestrial space or if the Earth would be without atmosphere. In the equatorial area, when the sun is in the zenith, the solar ray travels the shortest distance, meaning m = 1. For zenith angles θz (by zenith angle one could mean the angle between the location vertical and the direction towards the sun) from 0 to 70^o the air mass m can be calculated using the expression below:

$$m = \frac{1}{\cos\theta_z} \tag{2}$$

If θz is equal to 60^o, then the air mass m=2, ie the solar ray will travel a path trough atmosphere 2 times higher than for θz = 0^o. In the second situation the solar ray will be more attenuated and will transport less energy. This way could be explained the decrease of the solar radiation intensity in the north and south hemispheres, respectively, in comparison with the equatorial zone.

B. *Terrestrial irradiation*

Before describing the mathematical models for the solar radiation assessment one could emphasize some notions of celestial mechanics which describe position of the sun in sky roof at every moment (see Fig.2).

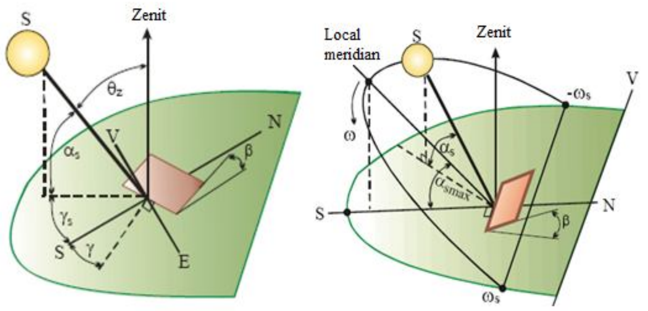


Fig. 2. Parameters describing the sun position in sky roof [6]

It is obvious that in one hour the sun travels in the sky an angle equal to 15^o, and its position at any time T can be expressed by the relationship below:

$$\omega = 15 \cdot (12 - T) \tag{3}$$

If the angles δ, φ and ω are known, then it can be determined easily the sun position in sky roof in a particular point, for any hour and any day, using the expressions below [13]:

$$\sin\alpha_s = \sin\delta\sin\varphi + \cos\delta\cos\varphi\cos\omega = \cos\theta_z \tag{4}$$

$$\cos\gamma_s = \frac{\sin\alpha_s \sin\varphi - \sin\delta}{\cos\alpha_s \cos\varphi} \tag{5}$$

In relationship (4) if the condition $\alpha_s = 0$ is imposed, one could calculate the horary angles of sunrise and sunset, respectively, by using the relationship:

$$\omega_s = \pm\cos^{-1}(-\tan\varphi \cdot \tan\delta) \tag{6}$$

For any day of the year, from (6) for the particular hour T it can be determined the horary angle ω, and knowing the site latitude φ, further might be determined the elevation angle of the sun α_s.

One could remind that the total irradiation incident on the surface of a body on Earth is equal to the sum of direct, diffuse and reflected components of irradiation (see Fig.3).

$$G_g = G_D + G_{dif} + G_R \tag{7}$$

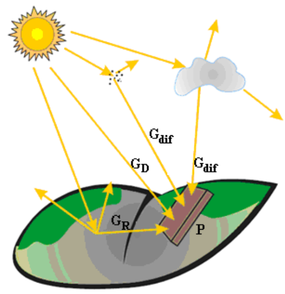


Fig. 3 Components of solar irradiation [6]

In literature one can find several models to determine the solar irradiation, still in this study there are particularized some empirical models for estimating the solar irradiation specific to a certain location, as follows below.

- ***Adnot model***, that models the global solar irradiation under conditions of a clear sky, by using the relationship [15]:

$$G_g = 951.39(\sin\alpha_s)^{1.15}\ [\text{W/m}^2] \tag{8}$$

This pattern has been verified using the meteorological data of Romania collected from the meteo stations of the Romanian capital Bucharest, and the Romanian cities of Iasi, Craiova, Timisoara and Constanta. [15].

- ***Haurtwitz model*** [15].

$$G_g = 1098 \cdot e^{\frac{0.057}{\sin\alpha_s}} \cdot \sin\alpha_s \quad [\text{W/m}^2] \tag{9}$$

ISBN: 978-1-61804-255-2

- ***Kasten model*** [10]

$$G_g = 910 \cdot \sin\alpha_s - 30 \quad [\text{W/m}^2] \tag{10}$$

- ***EIM empirical model*** [16]

$$G_g = G_0\left[1 - 0.4645 \cdot e^{-0.69\sin\alpha_s}\right] e^{-\frac{0.05211}{\sin\alpha_s}} \cdot \sin\alpha_s \tag{11}$$

The empirical model elaborated by Paulescu and Schlett [16] had been assessed using the meteorological data recorded by the meteo station of Timişoara.

All the empirical patters presented above need as inputs just the geographical coordinates of the location chosen and the temporal reference.

Applying the models presented as before for the location of Craiova city on the day of June 21 (as a day with high level of irradiation) and on the day of December 21 (as a day with low level of irradiation), respectively, the charts presents in Figs.4 and 5 have resulted.

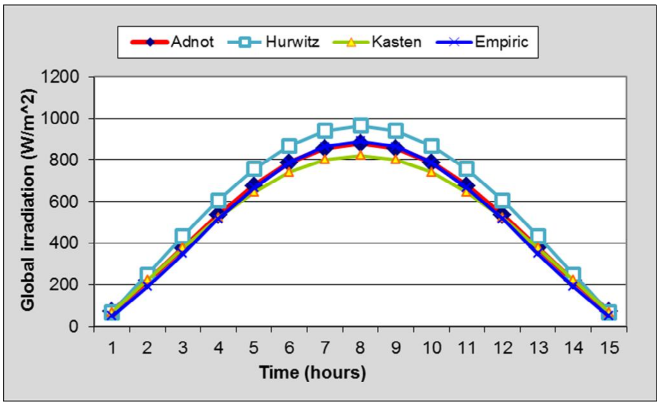


Fig. 4 Chart of global solar irradiation, in conditions of a clear sky, on June 21 for the location Craiova

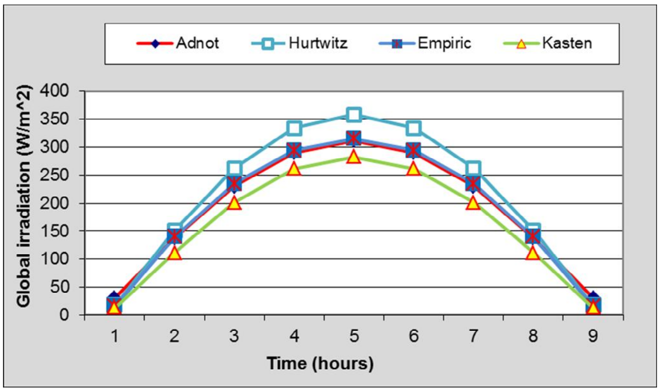


Fig. 5 Chart of global solar irradiation, in conditions of a clear sky, on December 21 for the location Craiova

From the analysis of the charts of solar irradiation in conditions of clear sky for the location Craiova it results that the Adnot model and Empirical model are identical for both cases and represents an average of the charts corresponding to Haurwitz model and Kasten model.

C. Solar irradiation absorbed by a photovoltaic panel without concentration

In Fig.6 is depicted the photovoltaic panel P directed toward south (γ=0). The surface of the panel is denoted by PV, and is inclined to the horizontal with the angle β.

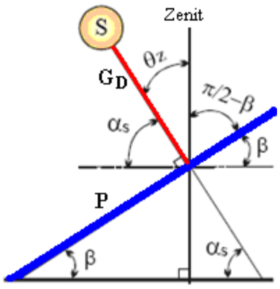


Fig. 6 Direct solar irradiation on the panel plane PV at the noon time: ω=0; γ=o;

From Fig.6 it tesults that $\theta_z = \beta$, and from the relationship (4) we obtain:

$$\cos\theta_z = \sin\delta\sin\varphi + \cos\delta\cos\varphi = \cos(\varphi - \delta) \tag{12}$$

Further one could determine the value of elevation angle of the panel PV:

$$\beta = \varphi - \delta \tag{13}$$

In Fig.7 it is depicted the direct solar radiation, G_D, on the horizontal plane (a), and $G_{D\beta}$, on a plane inclined to the horizontal with the angle β (b) [6].

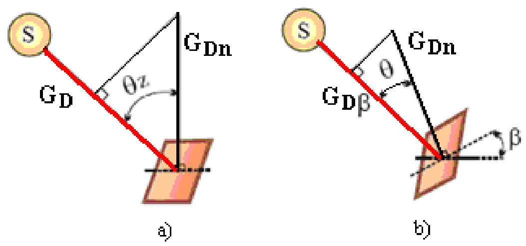


Fig. 7 Direct solar irradiation on a horizontal plane (a) and on an inclined plane (b)

Further there is denoted by G_{Dn} the normal radiation on the photovoltaic panel plane, in order to determine the ratio between G_D and $G_{D\beta}$. Hence, it is denoted the ratio between the direct radiation on an inclined plane and on a horizontal plane by $R_G = G_{D\beta} / G_D$.

From Fig.7 it results:

$$G_D = G_{Dn}\cos\theta_z \tag{14}$$

ISBN: 978-1-61804-255-2

$$G_{D\beta} = G_{Dn} \cos\theta \quad (15)$$

And the ratio R_G:

$$R_G = \frac{G_{Dn} \cos\theta_z}{G_{Dn} \cos\theta} = \frac{\cos\theta_z}{\cos\theta} \quad (16)$$

where θ is the angle of incidence of the solar ray – meaning the angle between the perpendicular on the plane taken into study and the direction of solar ray . For the horizontal plane one could highlight that $\theta_z = \theta$ (see Fig.7a).

For a plane arbitrary situated the functions cosθ and cosθz are expressed by function combinations of the angles δ, φ, β, γ and ω [13].

For $\beta = 0$ it results:

$$\cos\theta_z = \cos\varphi \cos\delta \cos\omega + \sin\varphi \sin\delta \quad (17)$$

For most of cases the photovoltaic panel is installed with the active face towards south and γ=0 for the north hemisphere, or 180^o – for the south hemisphere. Substituting relationship (17) in expression (15) one could obtain the relation below:

$$R_G = \frac{\cos(\varphi - \beta)\cos\delta \cos\omega + \sin(\varphi - \beta)\sin\delta}{\cos\varphi \cos\delta \cos\omega + \sin\varphi \sin\delta} \quad (18)$$

With the calculated value of the ratio R_G it will be determined the direct component of the solar radiation on the panel plane PV:

$$G_{D\beta} = R_G \cdot G_D \quad (19)$$

The other two components of solar irradiation – diffuse and reflected are established from the isotropic model of sky roof proposed by Liu and Jordan in 1960 and modified by Klein in 1977 [17].

The diffuse radiation on the inclined plane of the panel, $G_{dif\beta}$ will be calculated with the formula:

$$G_{dif\beta} = \frac{1}{2}(1 + \cos\beta)G_D \quad (20)$$

where G_D is the direct radiation on a horizontal plane calculated on basis of one of the previous patterns.

The reflected radiation on the inclined plane will be calculated with the relationship below:

$$G_{R\beta} = \frac{1}{2}(1 - \cos\beta)\rho G_g \quad (21)$$

where:

ρ is the reflection coefficient of the Earth surface; and

Gg is the global radiation on a horizontal surface.

Consequently, the global radiation on the inclined plane of the panel PV is equal to the sum of three components: direct, diffuse and reflected on the same plane [17]:

$$G_{g\beta} = R_G G_D + \frac{1}{2}(1 + \cos\beta)G_D + \frac{1}{2}(1 - \cos\beta)\rho G_g \quad (22)$$

Taking into consideration the presented model, the components of solar radiation absorbed by a photovoltaic panel arbitrary oriented and disposed in the location Craiova have been calculated.

Hence, in Fig.8 there are represented the solar radiation components calculated for June 21, and in Fig.9 the same components for December 21 of the year.

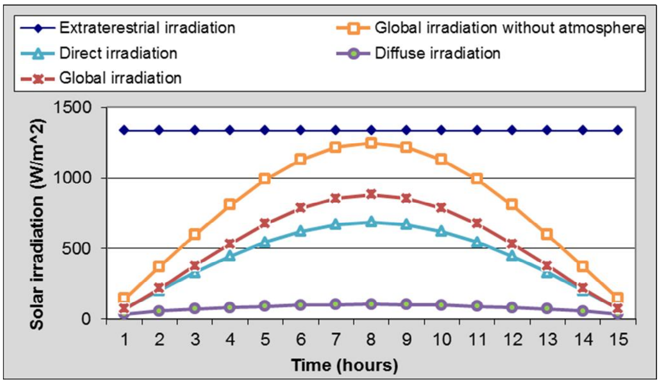


Fig. 8 Solar irradiation absorbed by a PV panel located in Craiova city on June 21

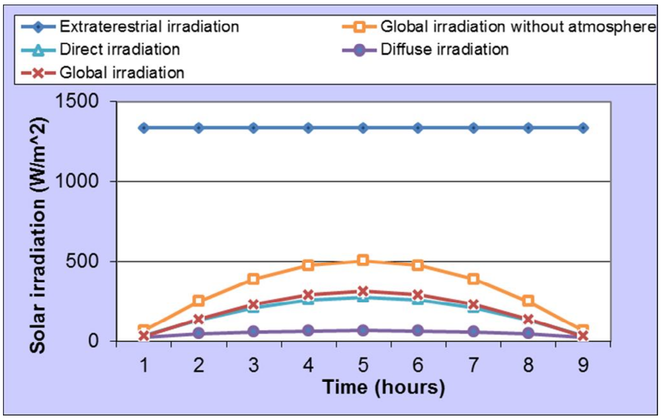


Fig. 9 Solar irradiation absorbed by a PV panel located in Craiova city on december 21

The analysis of the charts following the models' simulation for a comparison with the irradiation values indicated on the

ISBN: 978-1-61804-255-2

maps pointed out by European Union [19] for Romania emphasized that for Craiova location there are not obtained major difference, that implying the assertion of the correctness of the models adopted in order to estimate the solar irradiation.

III. Mathematical Model of Solar Radiation Absorbed by Photovoltaic Panel with Low Concentration

In order to estimate the solar irradiation absorbed by PV panel is necessary to be described the geometrical model of the low radiation concentration system [8].

The low radiation concentration system consists in two vertical mirrors disposed symmetrically in the lateral extremities of the PV panel. This system is similar to the system ″WS Heliots with DoubleSun″ [18], (see Fig.10).

Fig. 10. WS Heliots system, with DoubleSun technology [18]

The geometrical model of the concentration system is depicted in Fig.11. The solar rays reflected by each mirror cover a half of the panel surface. Thus, the two lateral mirrors reflect the solar light on the entire surface of the PV panel.

In order to describe the geometry of the LCPV system considered there have been denoted the following quantities (see Fig. 11) [1]:

- x is the angle between the mirror and the photovoltaic module, and is a constant parameter;
- h is the maximum incidence angle created by the solar ray with the normal to the photovoltaic arrays;
- k represents the ratio between the mirrors' width (Lm) and the photovoltaic module width (Lp);
- c1, c2 are the width coefficients of PV module brushed by the rays reflected by the mirror;
- kl is the longitudinal deviation coefficient, defined as the ratio between the additional length of the mirror (necessary for the compensation of the deviation of solar rays reflected, caused by the elevation deviations of the PV module from the solar elevation) and the photovoltaic module width.

The direct radiation received normally by the inclined plane, provided with concentrator elements type lateral mirrors is described by the relation [8]:

$$G_{D\beta_{conc}} = G_{D\beta} + \sum G_{M_{1,2}} \tag{23}$$

where:

$G_{M1,2}$ is the irradiation reflected by the two mirrors

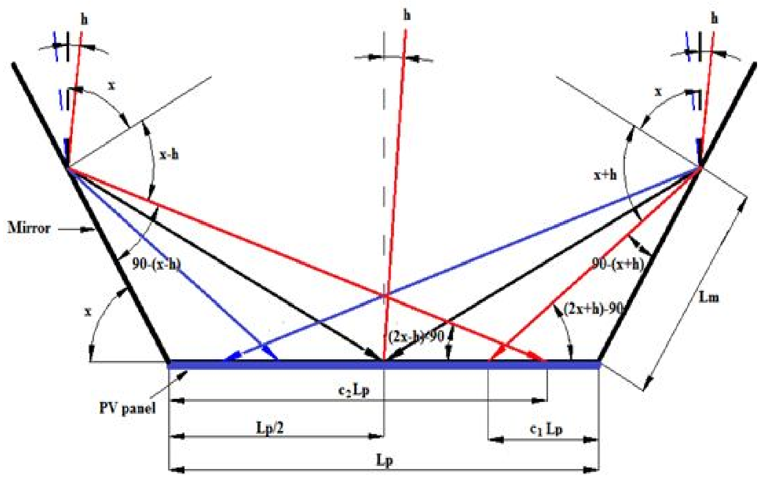


Fig. 11 Geometric model of LCPV system [1]

$$G_{M_{1,2}} = G_D \cdot \cos\left(h_{R_{1,2}}\right) \tag{24}$$

where $h_{R1,2}$ is the incidence angle formed between the ray reflected by each mirror and the normal to the photovoltaic panel.

The other components of the solar irradiation on the PV panel plane are presented above.

Accordingly, the graphical evolution of the solar irradiation absorbed by the PV panel with a concentration system, for the same conditions as before, are depicted in Figs. 12 and 13.

ISBN: 978-1-61804-255-2

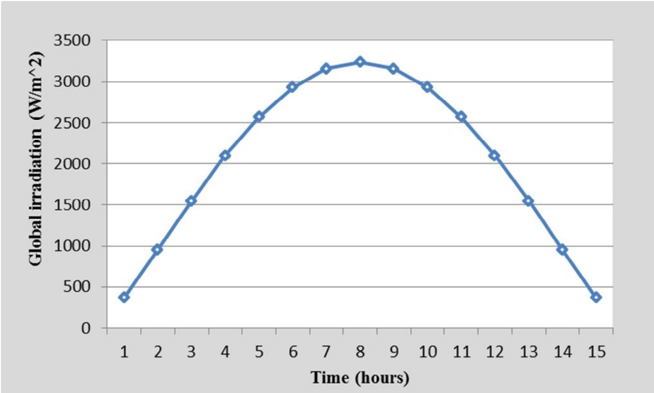


Fig. 12 Total irradiation absorbed by the PV panel with concentration system on June 21

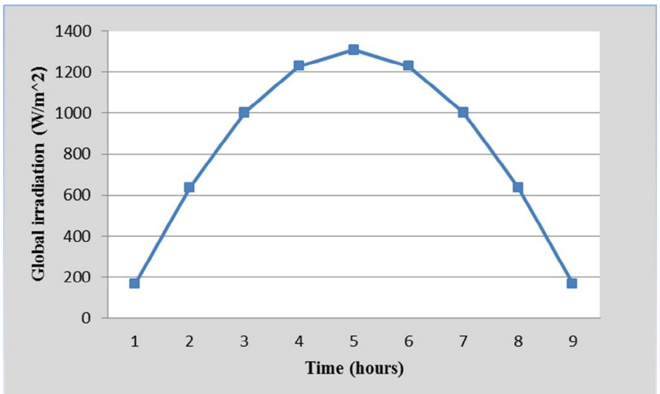


Fig. 13 Total irradiation absorbed by the PV panel with concentration system on December 21

In the framework of performed simulations have been particularized mathematical models for a certain location for the days with extreme values of the solar irradiations (June 21 and December 21, respectively), since this way one could easily verify the correctness of the patterns presented.

I. Conclusion

This paper presents some of the existing models in the literature in order to address meaningfully the solar irradiation assessment. These patterns have been particularized for the conditions specified for a certain location, namely Craiova city of Romania.

Validation of these models was performed by numerical simulation.

Correspondingly, from the charts following the simulations one could highlight several conclusions:

- the models Adnot and Empiric for the global irradiation assessment can be adapted in the best way at the conditions of the location chosen for this study;
- the values of solar irradiations obtained through the simulations are close enough to those indicated on the maps elaborated by professional institutes for the site took into study;
- during the travel through the atmosphere the solar rays decrease intensity as they approaching the Earth;
- the values of the solar irradiation on the PV panel plane are roughly 3 times higher than those on the PV panel plane without a concentration system.

Although the simulation results emphasize that the models presented might be utilized for the calculation of the solar irradiation specific to the location chosen, experimental tests are imposed. This aspect will be taken into consideration in a sequel of this work.

Acknowledgment

This work was partially supported by the grant number 29C/2014, awarded in the internal grant competition of the University of Craiova.

References

[1] I. L. Alboteanu, F. Ravigan, S. Degeratu, C. Sulea, “Aspects of designing the tracking systems for photovoltaic panels with low concentration of solar radiation” *Computational problems in Engineering II, 2014*, Springer-Verlag,in press.

[2] I. L. Alboteanu, *Advanced stand-alone photovoltaic system*, Craiova, 2013, “Universitaria”, Publisher.

[3] I. L. Alboteanu, G. Manolea, Fl. Ravigan, “Employement of photovoltaic energy for lighting vehicle railways”, *Environmental problems and development*, Bucharest, 2008, pp.104-110.

[4] C. Bratu, “Evaluation of solar irradiance to a flat surface arbitrary oriented”, *Annals of the University of Craiova, Electrical Engineering series*, No. 32, 2008, pp. 310-314.

[5] V. Bădescu, “Calculation of direct solar radiation on tilted surface”, *Solar energy*, 1992.

[6] I. Bostan, V. Dulgheru, I. Sobor, V. Bostan, A.Sochirean, *Renewable energy conversion systems*, Chisinau, “Tehnica-Info” Publisher, 2007.

[7] G. Grasso, F. Morichetti, A. Righetti, S.M. Pietralunga, “Trackless LCPV modules: A competitive solution”, *Photovoltaic Specialists Conference* (PVSC), 2012 38th IEEE, ISSN: 0160-8371, pp. 2048 -2051.

[8] I. Hermenean, I. Vişa, A. Dută, D. Diaconescu, “Modelling and Optimization of a Concentrating PV-Mirror System”, *Renewable Energy and Power Quality Journal*, No.8, April, 2010.

[9] I. Hermenean, I. Vişa, A. Dută, D. Diaconescu, “Modeling and Optimization of a CPV System with Equatorial Tracking”, Bulletin of the Transilvania University of Braşov, 2010, Series I: Engineering Sciences;

[10] F. Kasten, A.Young, “Revised optical air mass tables and approximation formula”, *Applied optical*, 1989.

[11] A. Luque, S. Hegedus, “Handbook of Photovoltaic Science and Engineering”, Wiley- VCH, 2003.

[12] A. Luque, L.V. Andreev, *Concentrator Photovoltaics*, Berlin Heidelberg. Springer-Verlag, 2007.

[13] R. Messenger, J. Ventre, *Photovoltaic System Engineering*, CRC Press, 2004, Sec. Edition.

[14] M. Paulescu, Z. Schlett, *Photovoltaic conversion of solar energy*, Timişoara,. “MIRTON” Publisher, 2001.

[15] M. Paulescu, *Algorithms for estimating solar energy*, Bucharest “Matrix Rom”, 2004.

[16] M. Paulescu, Z. Schlett, “Performances assement of global solar irradiation models under Romanian climate”, *Renewable energy*, 2003.

[17] B. Y. H. Liu, R C. Jordan, “The inter-relationship and characteristic distribution of direct, diffuse and total solar radiation”, *Solar Energy* 1960; 4(3):1–19.

[18] *** http://ws-energia.pt/np4PT/home.html

[19] *** http://re.jrc.ec.europa.eu/pvgis/apps4/pvest.php?lang=en&map=europe

Automated decision-making system for power equipment state assessment

Alexandra I. Khalyasmaa, Stepan A. Dmitriev and Sergei E. Kokin
Ural Federal University named after the first President of Russia B.N. Yeltsin

Abstract—**The article presents the new approach to problem solving of power equipment actual state assessment on power plants and substations for automated decision-making systems. Fuzzy neural network architecture is presented on the base of Takagi-Sugeno adapted fuzzy control method for assessment of power equipment actual state. Implementability of designed model and ANFIS applicability for mathematical model implementation are proved by means of calculation example based on technical diagnostics and tests data. The article also discusses issues related to the formation of the training sample.**

Keywords—actual state assessment, hybrid neural network, training sample, membership functions, ANFIS.

I. INTRODUCTION

Nowadays assessment of power equipment actual state on power plants and substations is a crucial problem. Herewith actual equipment state is a data set of tests, diagnostics and other operation information about equipment, which characterizes the current state of equipment with consideration of data dynamics.

Firstly, it is related to the problem of high equipment deterioration on power plants and substations in Russia and obvious correlation [1] and impact of substations (stations) electric part on different system parts both internal substations parts and external power system. Total deterioration of Federal Grid Company networks is 48,5%, including substation equipment deterioration − 60%, power lines deterioration − 41,9%. [2]. Average HEP (hydroelectric plants) equipment age is 5 years, age classification: under 30 years – 22,3 %; from 31 to 50 years – 56,8 %; more than 50 years – 20,9 %. Approximately 60 % of TEP (thermoelectric plants) steam turbines are overaged; 50 % of hydraulic turbines exceeded standard operation time [3].

Secondly, it is related to the problem of preventative and predictive maintenance system application and transition to equipment maintenance by actual state. In spite of the fact that nowadays preventative and predictive maintenance system is used on many power facilities, it has a number of sufficient disadvantages, and the principal disadvantage consists in no differentiated approach to power equipment with consideration of its design variant, state, operation modes, operation conditions etc. It can result in unreasonable repairs' labor-output ratio (in case of operable and serviceable actual state) of equipment or conversely it can result in failures and defects missing (in case of operable but non-serviceable state) in equipment.

Thirdly, nowadays works on measuring systems improvement and installation of additional sensors, monitoring systems for particular equipment types on power plants and substations with on-line data accessing, are performed in power industry. On-line data accessing allows defining controlled parameters and estimating these parameters' impact not only on equipment but also on substation (station) operation as a whole in case of particular analysis of obtained data. The use and analysis of obtained data will give valuable and verified results. It may ultimately allow solving the problem of assessment of equipment residual operation life to a high degree of accuracy.

Modern systems of power equipment state assessment on power plants and substations are automated expert systems designed for solving generally two problems types: determination of equipment functional state for adjustment of equipment life cycle and technical-and-economic problems. These problems solving will not only improve power systems operation efficiency but also provide an adequate tool for business assets control of grid (power grid) companies. Unfortunately, as of today, systems for integrated solving of these two problems are not developed.

In European analogs of such systems, as opposed to Russian ones, service life extension of power equipment is not a primary task, because of equipment replacement after expiration of service time specified by the manufacturer. Furthermore due to rather sufficient differences in standard documentation for power equipment maintenance, diagnostics and tests, equipment configuration and operation the use of foreign systems of power equipment assessment is not suitable for Russian power systems. There are few expert systems for power equipment assessment, which are used on real power facilities, in Russia, and most of them are designed for solving the problem of separate equipment units' state assessment (for example, state assessment of nothing else but transformers etc.). Existing systems are implemented as different mathematical models: from simplest models based on usual production rules to more complicated models, for example models based on Bayes method or as shown in the [4].

Along with all obvious advantages systems existing in Russia have a lot of sufficient disadvantages:

1) systems are focused on solving the specific problems of particular customers (for specific schemes, specific equipment etc.) and as a rule they can't be used on other similar objects without extensive re-work;
2) multiscale and multipoint information is used, it may cause possible assessment uncertainty;
3) assessment criteria dynamics of equipment state is not considered, in other words systems are not educable.

All disadvantages mentioned above deprive modern power equipment assessment systems of versatility and therefore current situation in Russian power industry leads to improvement of existing systems or searching of new mathematical methods for technical state determination. In other words, new tools for quantitative and qualitative assessment of power equipment on power plants and substations with the following characteristics are required:

1) statistics gathering concerning equipment faults and failures and statistics analysis (self-analysis) and conformity search;
2) the use of different diagnostics and tests methods, including application of information technologies for technical maintenance and repair control; [5] Increasing demand for providing power equipment maintenance reliability is so obvious that application of methods for equipment faults determination is undisputable.
3) informational systems implementation should be supported by energy companies assets;
4) system applicability for any problem solving – system can be used for other similar objects without extensive re-work – system versatility;
5) consideration of assessment criteria dynamics of actual equipment state – system learnability.

In such a manner creation of automated decision-making system for actual equipment state assessment on power plants and substations is obviously a crucial problem. And system implementation by means of hybrid networks based on diagnostics and tests data assists in the present system exhibition of all characteristics mentioned above.

II. Network Architecture

The primary objective for automated decision-making system creation is its model creation, in particular in this case development of hybrid neural network architecture on the base Takagi-Sugeno adaptive fuzzy control method for its implementation.

A. Network structure

The present network structure was described in detail by the authors in [6]-[8]. The basic concept is in that equipment on substation (station) is divided into groups which are presented in particular hierarchy: complex objects (for example 110 kV switchgear), primitive objects (for example, circuit breaker) and objects' composite units (for example arc extinguish chamber). On the base of data concerning actual state of composite units, primitive objects and complex objects state assessment is performed on all 3 levels: from primitive to higher level by means of hybrid neural networks. Herewith on each level not only state assessment but also determination of possible faults is performed. As a result we obtain integral state analysis of substation (station) as a whole.

B. Operational procedure of the network

Hybrid neural network architecture for automated decision-making system for power equipment actual state assessment consists of 5 layers. General form of hybrid neural network structure for primitive object is presented in Fig. 1.

On *the first layer* fuzzification of input parameters is performed – membership functions are determined for each parameter in accordance with technical diagnostics method and types of tests depending on data availability. Each membership function characterizes each possible state of the object under consideration. The type and number of membership functions can vary with diagnostics (tests) and object types.

Whereas for each diagnostics and tests type specific diagnostics rules are introduced (rules base is created) by means of the following production rules

$$if\ (x_1\ is\ D_1^k\ and\ ...and\ x_N\ is\ D_N^k)\ then\ z\ is\ y_N \qquad (1)$$

where $k = 1,...,K$, where K - number of fuzzy rules; D_i^k - fuzzy sets, where $D_i^k \in X_i \subset R,\ i = 1,...,N$; $x_1,...,x_N$ - input variables; y_N - output variables.

On *the second layer* weighting coefficients are defined on the base of membership functions defined on the previous layer (by average weighted estimate method).

The third layer is characterized by training algorithm in the course of which polynomial weights are corrected.

According to a number of calculations hybrid training method is an optimal training method for presented problem. Hybrid training is the method which integrates error back propagation method and least square method.

In error back propagation method error is distributed from network outputs to inputs, in other words in the opposite direction to signals propagation in normal operation.

Least square method (LSM) – is a mathematical method, based on minimization of functions squares sum deviation from desired variables. The present method is described in

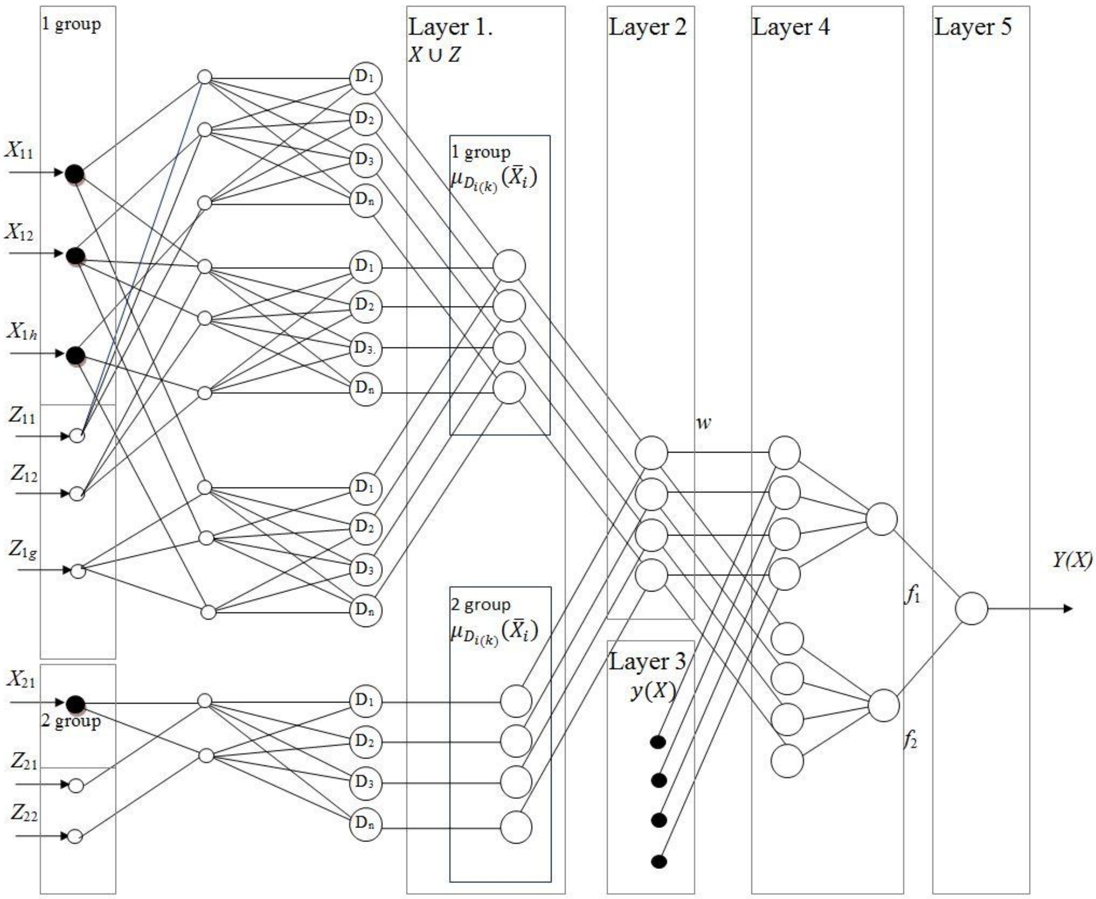


Fig. 1 hybrid neural network architecture for automated decision-making system for power equipment state assessment

detail in [1].

The fourth layer consists of two neurons-integrators: the first one is responsible for a weights sum of investigation subject state membership; the second one calculates the weighted sum of signals from output aggregative function from the 3 layer.

The fifth layer consists of one neuron, its operation result is presented by output aggregative function of the following type

$$y_i(x) = p_{i0} + \sum_{j=1}^{N} p_{ij} x_j, \tag{2}$$

where N – number of X set parameters; p_{ij} – parameters of Takagi-Sugeno polynomials (TSK).

III. Calculation Example

Training sample representativeness (structuredness) and membership functions type can markedly impact on calculation results. Therefore before transition to adaptive neuron fuzzy inference system (ANFIS) it is necessary to select optimal type of membership function and carry out training sample analysis in advance.

A. Creation of training sample

Training sample in the present problem is a set of statistical data for which membership to particular state is known a priori.

Training sample creation for any problem including problem of equipment functional state determination reduces to problem of the present sample optimization.

Optimal training sample should possess the following 3 properties:

be sufficient – number of training examples should be sufficient for training;

be varied – sample should have a large number of different input-output combinations considering the fact that all classes typical for initial set are presented;

be uniform – examples should be presented in approximately equal proportions.

Let us consider the following example. In [9] power transformers state assessment was implemented on the base of data obtained by chromatographic analysis of gases dissolved in oil, by means of ANFIS. In this case relations of gases pairs were taken as inputs: C_2H_2/C_2H_4 (will be designated as A), CH_4/H_2 (B), C_2H_4/C_2H_6 (C), and possible transformers faults were taken as outputs. Main results are presented in Table 1.

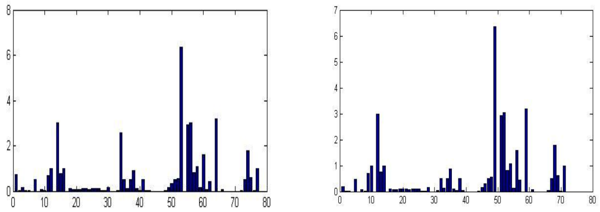
Table1 - ANFIS info

ANFIS info	Values
Number of nodes	1518
Number of linear parameters	2916
Number of nonlinear parameters	108
Total number of parameters	3024
Number of training data pairs	**78**
Number of fuzzy rules	729
Average testing error	0,064

Calculation result shows that error magnitude is 6,4%.

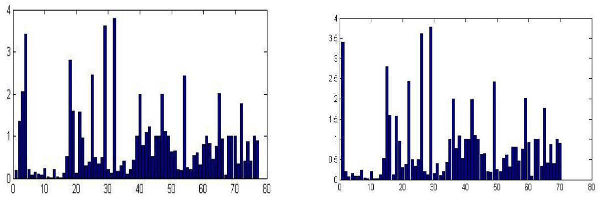
In the present article we would like to analyze different training examples and prove that error in a greater degree depends on sample representativeness.

We should first analyze the sample which was used in [9]. The sample consisted of 78 training pairs. Diagrams of values for each input are presented in Fig. 2a-4a.



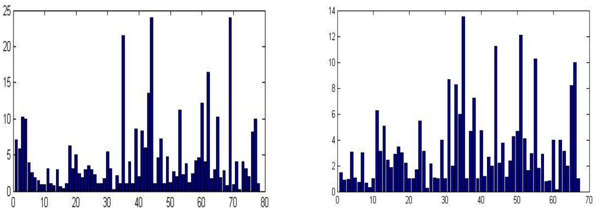
a b

Fig. 2 values diagram for A



a b

Fig. 3 values diagram for B



a b

Fig. 4 values diagram for C

It can be seen on all three figures that some values stand out sharply. In the present article runs occurrence nature is not considered, only qualitative and quantitative analysis of the sample is carried out. In order to reduce an error it is sufficient to exclude main runs.

For runs excluding any method of statistical data analysis can be used. Error magnitude will also depend on analysis method. In this particular case analysis was performed on the base of calculation of mathematical expectation and dispersion of sample values, then main runs were excluded (Fig. 2b- 4b). Results of runs excluding obtained by ANFIS analysis are presented in Table 2.

B. *Membership functions selection*

Type of membership function impacts on system operation results [10], therefore it is necessary to carry out preliminary analysis with the use of different membership functions for the present system. As in the present problem analysis is performed on the base of chromatographic analysis data, and according to [11] boundary values for gases relations are in general assigned as values with double limiting, it was decided to use trapezoidal and Pi-shaped membership functions (in the form of curvilinear trapezoid). Calculation results are presented in Table 2.

Table 2 – Calculation results

ANFIS info	Values	
Membership function type	Trapezoidal	Pi-shaped
Number of training data pairs	**74**	**74**
Number of nodes	1518	1518
Number of linear parameters	2916	2916
Number of nonlinear parameters	108	108
Total number of parameters	3024	3024
Number of fuzzy rules	729	729
Average testing error	**0,0091**	**0,0018**

Calculation results show that Pi-shaped membership functions are optimal functions for the present problem, and after runs excluding error magnitude is 0,0018 while in case of trapezoidal membership function error magnitude is 0,0091.

Let us also remark that as compared to result obtained in [9] training sample was reduced by 4 pairs – from 78 to 74 pairs, but error was reduced from 0,064 to 0,0091 –practically by one order.

IV. Conclusions

As a result of presented analysis it can be concluded that training sample in decision-making system for actual equipment state assessment should be sufficient, but “the more the better” principle is inappropriate. The sample should be also varied and uniform.

Moreover, for efficient operation of the present system training sample should be processed in advance and all runs should be excluded. Let us remark that runs excluding should be bidirectional – both very high and very low values should be excluded – it will exclude their impact on result to the maximum.

Only in case of fulfillment of all conditions mentioned above equipment membership to any state will be sufficient criterion for sample certainty.

Analysis of runs occurrence causes in training sample for the problem under investigation will be considered in the next article.

References

[1] S. A. Dmitriev, S. E. Kokin, A. I. Khalyasmaa. “Power-information models of operation and development of megapolises power supply systems”. *Advances in Environmental Sciences, Development and Chemistry*, 2014, pp. 145-150.

[2] RAO "UES of Russia". *"The main provisions of (concept) technical policy in the Russian power industry for the period up to 2030"*, 2008. [Online]. Available: http://www.rao-ees.ru/ru/invest_inov/concept_ 2030.pdf.

[3] (Journal Online) S. Krilov (2014, february). "Energy requires change". *Energy and Industry of Russia. №4 (216)*. Available: http://www.eprussia.ru/epr/216/14739.htm.

[4] S. A. Dmitriev, A. I. Khalyasmaa, S. E. Kokin, "Substation equipment state assessment using indicative analysis (Published Conference Proceedings style)," in *Proc. of the 6th IASTED Asian Conference on Power and Energy Systems*, AsiaPES, 2013, pp. 240-245.

[5] B. A. Kats. "A preventive maintenance system: history lessons". *Industrial services, 2013, №4,* pp. 35-41.

[6] Khalyasmaa, A. I., S. A. Dmitriev, S. E. Kokin, "Assessment of power transformers technical state based on technical diagnostics," *Applied Mechanics and Materials*, 2014, vol. 492, pp. 218-222.

[7] A. I. Khalyasmaa, S. A. Dmitriev, "Power equipment technical state assessment principles," *Applied Mechanics and Materials*, 2014, vol. 492, pp. 531-535.

[8] A. I. Khalyasmaa, S. A. Dmitriev, S. E. Kokin, S. A. Eroshenko. "Fuzzy neural networks' application for substation integral state assessment".*WIT Transactions on Ecology and the Environment, 2014,* pp. 599–605.

[9] A. I. Khalyasmaa, A. A. Aminev, A. A. Sergeev, S. A. Dmitriev, D. I. Bliznyuk. "Equipment state assessment system based on ANFIS". *Applied Mechanics and Materials, 2014,* pp. 531–535.

[10] A. I. Khalyasmaa, S. A. Dmitriev, S. E. Kokin, "Membership functions for the formation of the electrical equipment state assessment for power stations and substations," *Advanced Materials Research*, 2013, vol. 806-806, pp. 663-666.

[11] RAO "UES of Russia". *"GD 153-34.0-46.302-00 Guidelines for the diagnosis of developing defects transformer equipment as a result of chromatographic analysis of gases dissolved in the oil". 2011.*

ISBN: 978-1-61804-255-2

How Reproducible – and thus Verifiable – is the Environmental Performance Index?

Tatiana D. Tambouratzis, Kyriaki S. Bardi, Angeliki G. Mathioudaki

Abstract—**Since 2006, the Environmental Performance Index (EPI) has been devised and used extensively for expressing the environmental sustainability of the participating countries, in both absolute and relative terms. Starting with 16 indicators that correspond to the raw environment-related data of each participating country, the EPI is calculated in a hierarchical manner involving an initial and two intermediate stages, each stage implemented via a first-degree polynomial approximation. In the interest of reproducing – and, thus, verifying – the aforementioned process, each stage is replicated using first- (and higher-, if necessary) degree polynomial approximation, complemented by general regression artificial neural networks (GRNNs) for non-parametric free-form fitting when the polynomial(s) is/are not found to be sufficiently accurate. The results of this investigation put forward a means of deriving the EPI, without however managing to reproduce the original values or rankings of the participating countries. Further to its capability of accurately reproducing the EPI value of a participating country, this procedure is of special interest as it puts forward a means of directly calculating the EPI value of a non-participating country from compatible raw data.**

***Keywords*—**Environmental Performance Index (EPI), General Regression Artificial Neural Networks (GRNNs), Polynomial Approximation, Sustainability Assessment, Sustainable Development Indicators.

I. INTRODUCTION

IN the last 50 years, the awareness of sustainable development (SD)[1] has grown significantly, thus raising public interest and awareness, as well as promoting a concentrated scientific initiative towards uncovering the factors that maximise sustainability, not only at the level of countries (or territories) [1-3], but further – and especially in the long run – at the global level.

A hierarchical procedure is implemented for directly comprehending, expressing, and comparing the raw data that is available for the participating countries; this begins with the raw data, and culminates in a single-valued cumulative index that quantitatively expresses the country's overall SD. Such a procedure facilitates the comparison of different countries in terms of their SD, while it can also promote their grouping into sets of countries with similar environmental sustainability characteristics.

A variety of SD indicators have been developed over the years, among them the *Global Scenario Group*, the *Wellbeing Index*, the *Sustainable Society Index*, the *Human Development Index*, the *Ecological Footprint*, the *Environmental Sustainability Index* (ESI), and the *EPI* to name but a few [6-7].

TABLE I
THE COUNTRIES USED FOR THE EVALUATION OF THE PILOT EPI 2006

Bolivia	Guinea	New Zealand	Thailand
Brazil	Guinea-Bissau	Nicaragua	Togo
Bulgaria	Haiti	Niger	Trinidad & Tobago
Burkina Faso	Honduras	Nigeria	Tunisia
Burundi	Hungary	Norway	Turkey
Cambodia	Iceland	Oman	Turkmenistan
Cameroon	India	Pakistan	Uganda
Canada	Indonesia	Panama	Ukraine
Central Afr. Rep.	Iran	Papua New Guinea	United Arab Em.
Chad	Ireland	Paraguay	United Kingdom
Chile	Israel	Peru	United States
China	Italy	Philippines	Uzbekistan
Colombia	Jamaica	Poland	Venezuela
Congo	Japan	Portugal	Viet Nam
Costa Rica	Jordan	Romania	Yemen
Côte d'Ivoire	Kazakhstan	Russia	Zambia
Cuba	Kenya	Rwanda	Zimbabwe
Cyprus	Kyrgyzstan	Saudi Arabia	
Czech Rep.	Laos	Senegal	
Dem. Rep. Congo	Lebanon	Sierra Leone	
Denmark	Liberia	Slovakia	
Dominican Rep.	Madagascar	Slovenia	
Ecuador	Malawi	South Africa	
Egypt	Malaysia	South Korea	

The focus of this research is on the pilot EPI 2006, as this index constitutes the basis of all the subsequent versions of the EPI [8]. The investigation involves two distinct parts, namely

(a) the verification of the methodology described in the report of the Pilot EPI 2006 [8], and
(b) the reproduction of the Pilot EPI 2006 through the steps described in [8], thus putting forward a means of directly calculating the EPI of a non-participating country.

The authors are with the Department of Industrial Management & Technology, School of Shipping and Industry, University of Piraeus, 107 Deligiorgi St, Piraeus 185 34, Attiki, Greece (phone: +30-210-4142423; fax: +30-210-4142392; e-mail: tatianatambouratzis@gmail.com).

[1] SD encompasses the economic, social and ecological development at the regional, national and international scale [4-5].

The following text is organized as follows: Section II introduces the Pilot EPI 2006, outlines its background, describes pre-processing from raw data/indicators to proximity-to-target data, and details the means of deriving the categories and broad objectives that correspond to the intermediate stages of the hierarchical construction of the EPI, as described in [8]; section III presents the tools and methodologies used here for verifying as well as predicting the EPI; section IV critically explains the obtained results, and; finally, section V puts forward some points that require further investigation.

II. The Pilot EPI 2006

A. The History of the EPI

The Pilot EPI 2006 has been put forward as a tool for assessing the SD aspect of the environmental performance of a total of 133 countries worldwide. The index was devised by

(a) the Yale Center for Environmental Law and Policy (YCELP) of Yale University, and

(b) the Center for International Earth Science Information Network (CIESIN) of Columbia University, in collaboration with

(c) the World Economic Forum (Geneva, Switzerland), and the support of

(d) the Samuel Family Foundation (Toronto, Canada) [8].

Up to date, the EPI has been evaluated and published in 2006, 2008, 2010, 2012 and 2014, with the differences observed in each version of the index being due to the number (and identity) of the countries involved, as well as to the nature and focus of the intermediate constructs, namely policy categories, and broad objectives.

In this piece of research, the Pilot EPI 2006 is investigated. It is worth mentioning that, although the Pilot EPI 2006 was launched as a continuation of the Environmental Sustainability Index (ESI) 2005, the two indices have significant differences, the most important of which being that the EPI constitutes an absolute means of measuring how close a country's SD performance is to specific international goals [8], whereas the ESI evaluates, ranks and groups different countries in terms of their relative sustainability [9].

B. The EPI Structure

The Pilot EPI 2006 is assembled hierarchically, in the manner described in the introduction and shown in Table II. The index is built up of two broad objectives, Environmental Health, and Ecosystem Vitality & Natural Resource Management (first column of Table II). The two broad objectives are constructed from six policy categories (third column of Table II): the Environmental Health broad objective comprises a single policy category, whereas the Ecosystem Vitality & Natural Resource Management broad objective is composed from five policy categories. The weights of the policy categories for the formation of each broad objective (and, subsequently, of the EPI) are given in [8] and presented in the second column of Table II. Finally, each policy category combines between two and five component-specific indicators, with the six policy categories constructed from 16 indicators (fifth column of Table II). Furthermore, three indicators participate in the formation of two (i.e. more than a single) policy categories. The weights given to each proximity-to-target parameter for the formation of the policy categories are presented in the fourth column of Table II.

TABLE II

THE CONSTRUCTION OF THE EPI 2006 IN TERMS OF TWO COMPONENTS, SIX POLICY CATEGORIES AND SIXTEEN INDICATORS

Broad Objective	Weights ←	Policy Category	Weights ←	Proximity-to-Target
Environmental Health	0.5	Environmental Health	0.13	Urban Particulates
			0.22	Indoor Air Pollution
			0.22	Drinking Water
			0.22	Aequate Sanitation
			0.21	Child Mortality
Ecosystem Vitality & Natural Resource Management	0.1	Air Quality	0.5	Urban Particulates
			0.5	Regional Ozone
	0.1	Water Resources	0.5	Nitrogen Loading
			0.5	Water Consumption
	0.1	Biodiversity and Habitat	0.39	Wilderness Protection
			0.39	Ecoregion Protection
			0.15	Timber Harvest Rate
			0.07	Water Consumption
	0.1	Productive Natural Resources	0.33	Timber Harvest Rate
			0.33	Overfishing
			0.33	Agricultural Subsidies
	0.1	Sustainable Energy	0.43	Energy Efficiency
			0.1	Renewable Energy
			0.47	CO_2 per GDP

As mentioned in [8], the aforementioned hierarchical structure of the ESI 2006 has been implemented using environmental policy literature, expert judgment and the Millennium Development Goals [8].

C. EPI Evaluation

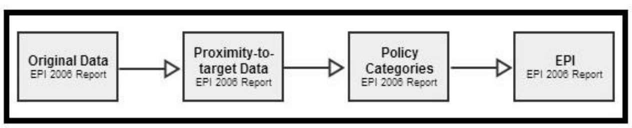
In order to construct the EPI, the raw data pertaining to the 16 indicators is initially transformed to proximity-to-target data using a variety of pre-processing procedures, including

ISBN: 978-1-61804-255-2

standardisation, winsorisation, extreme value removal, and box-cox family transformations [8]. Following the application of these numerical and statistical conversions, the six policy categories are derived, in turn, from the proximity-to-target data using Principal Component Analysis (PCA) and expert judgment. As mentioned in [8], PCA reveals three clear groups (Environmental Health, Sustainable Energy, and Biodiversity & Habitat) accompanied by the amount of contribution of each indicator to the policy category. The three remaining categories (Air quality, Water Resources and Productive Natural Resources) do not stand out during PCA, whereby expert judgment has been used for determining appropriate weights. After determining the weights of the proximity-to-target data, the six policy categories are evaluated as a linear combination of the indicators. Finally, the EPI score of each participating country is evaluated as the weighted average of the policy categories; it is worth mentioning here that, since the two broad objectives are believed to contribute equally to the formation of the EPI [8], they are equally weighted. As a result, the policy categories that create them also share equal weights, whereby the EPI score for each country is – in fact - evaluated as the weighted average of the policy categories. The four steps followed for the construction of the Pilot EPI 2006 are presented more succinctly in Figure I.

Uncertainty and sensitivity analyses have been performed for (a) verifying the general stability of the EPI values, (b) measuring the reliability and transparency of the Pilot EPI 2006, (c) identifying its sensitivity under different assumptions and, finally, thus ensuring that the Pilot EPI 2006 forms a trustworthy and useful tool for measuring SD.

FIGURE I
THE FOUR STEPS FOR THE EVALUATION OF THE PILOT EPI 2006



D. The Significance of the EPI

The Pilot EPI 2006 has been used as a measure of SD for the 133 participating countries (shown in Table I), thus allowing the evaluation of the progress of:

(a) each participating country towards SD in absolute (quantitative) terms
(b) all the participating countries in relative terms, thereby promoting comparisons as well as their ranking in terms of environmental sustainability.

Moreover, the Pilot EPI 2006 constitutes an auxiliary tool for indicating environmental issues as well as their relative priorities to the policy makers, while it can also be used for evaluating current policies of the countries in terms of SD, and for further determining the best policy practices.

III. VERIFICATION AND REPRODUCTION OF THE PILOT EPI 2006 METHODOLOGY

The present investigation of the Pilot EPI 2006 is divided into two distinct parts, namely the verification of the methodology described in [8], and the attempt to reproduce the Pilot EPI 2006 procedure - in terms of the numerical results of each of the three steps of Figure I - as faithfully as possible.

A. Verification of the EPI Methodology

As already mentioned in Section I, it is of special interest to identify the means of deriving the EPI values of the 133 countries from the initial 16 indicators (i.e. the raw data available for the 133 countries).

According to [8], the Pilot EPI 2006 is calculated as a weighted average of the policy categories, in other words a first-degree polynomial has been employed for producing the EPI values of the 133 countries. In a similar fashion, and again following [8], the policy categories are derived from proximity-to-target data via a first-degree polynomial approximation. Conversely, the methodology implemented in [8] for the transformation from raw data to proximity-to-target data is not adequately detailed.

The prediction/approximation techniques employed here verifying the aforementioned steps leading from indicators (raw data) to EPI values are:

(a) *The Report Method*, a faithful reproduction of the technique described in [8]. This technique is only possible for evaluating the policy categories and the EPI 2006, as only these first-degree polynomial coefficients are given in [8].
(b) *Polynomials of various degrees*. Since, as stated in [8], first-degree polynomials have been used, it is expected that the coefficients of the polynomial approximation should closely match the weights given in [8]. In the cases where the first-degree polynomials cannot accurately describe the relation between two consecutive steps, or the weights given by these polynomial do not match those of [8], polynomials of second, third, fourth, and fifth degrees have also been implemented, with the number of coefficients increases steeply for increasing degrees.
(c) *General regression artificial neural networks (GRNNs)*. Since the GRNN architecture is capable of implementing the “best” free-form (non-parametric) regression surface via its four-layer architecture, it constitutes an ideal tool for the cases where polynomial approximation of any reasonable order fails [11-13]. Accordingly, GRNNs have been implemented only when the polynomial approximation of (a-b) is not capable of duplicating the output values of [8].

ISBN: 978-1-61804-255-2

In all cases, prediction accuracy has been evaluated using 10-fold-cross-validation [14], with ten distinct polynomials and ten distinct GRNNs created for testing the entire dataset. The Pilot EPI 2006 dataset has been divided into ten parts of practically equal size[2], with nine parts used for creating the polynomial or training the GRNN, and the last part used for predicting the output using the created polynomial/trained GRNN. By repeating this procedure 10 times, so that each fold is used exactly once for testing and nine times for creating/training the corresponding methodology, a clear picture of the prediction capabilities of the polynomial and the GRNN approximation emerges. MATLAB 2009a [15] has been used for the implementations.

The results of the aforementioned three prediction/approximation techniques have subsequently been compared with the report Pilot EPI 2006 values that appear in [8]. The absolute differences between the predictions and the report Pilot EPI 2006 values have been calculated in each case, thus exposing the accuracy of each prediction/ approximation technique for each case (shown in Tables III through to VI).

As a final step, the direct evaluation/prediction of the EPI value from the raw data (i.e. without going through the intermediate steps) has also been tested. The rationale behind this endeavor is as follows: if this is possible, a means of accomplishing direct prediction of the EPI from the raw data becomes available; this constitutes in itself a finding of great value, since not only would the computational complexity of EPI evaluation be dramatically reduced, but – and more importantly - the direct and perfect prediction of the EPI value of a country not included in the Pilot EPI 2006 (but with available raw data compatible with those of the 133 participating countries) would be endured..

Case I: From Policy Categories to EPI

The accuracy of the derivation of the EPI from the policy categories is shown in Table III, demonstrating the superiority of the 1st degree polynomial approximation over higher-degree approximations; the absolute differences are such that they can be attributed to rounding errors. Furthermore, and equally important, the polynomial coefficients produced by the 1st degree polynomial closely match the weights given in [8] for the policy categories. It can thus be confirmed that a first-degree polynomial has been used for producing the weights leading from the policy categories to the EPI value.

TABLE III
ABSOLUTE DIFFERENCES OF CASE I

Case I	average	min	max	std
Report Method	0.031	0.000	0.080	0.019
1st Degree polynomial	0.032	0.000	0.083	0.020

[2] In this case, the Pilot EPI 2006 dataset has been ordered in ascending order of the EPI value, with the *i*th fold (*i*=1, 2, ..., 10) containing the data corresponding to the *i*th, (*i*+10)th, (*i*+20)th etc. participating country.

Case II: From Proximity-to-Target data to Policy Categories

The same three techniques have been used for predicting the policy categories from the proximity-to-target data. As stated in [8] and shown in Table II, different indicators have been used for the calculation of each policy category, thus requiring independent prediction of each category. The absolute differences between the predictions and the report data have been calculated independently for each category, and are shown in Table IV.

TABLE IV
ABSOLUTE DIFFERENCES OF CASE II

Case II	Optimal Technique	average	min	max	std
Environmental Health	1st Degree Polynom	0.028	0.000	0.093	0.018
Air Quality	Report Method	0.025	0.000	0.050	0.025
Water Resources	Report Method	0.024	0.000	0.100	0.026
Biodiversity & Habitat	Report Method	0.189	0.004	0.480	0.114
Productive Natural Resources	GRNN	5.536	0.000	34.640	6.468
Sustainable Energy	Report Method	0.166	0.000	0.351	0.086

Table IV shows that the optimal prediction technique differs for each policy category: the Report Method is optimal for four out of the six policy categories, whereas the first degree polynomial and the GRNN, respectively, are superior for the Environmental Health, and Productive Natural Resources policy categories, respectively. The latter finding is quite at odds with [8], as it contradicts the statement that all policy categories constitute linear combinations of the proximity-to-target data with the coefficients given in [8].

It is also quite surprising that significant differences are found between the results obtained from the Report Method and the ones given in [8]; for instance, the sum of absolute differences varies from 3.2 for Water Resources to 784.856 for the Productive Natural Resources.

Case III: From Raw data to Proximity-to-Target data

The final step-by-step case refers to the prediction of the proximity-to-target data from the raw data. As already mentioned, the order (or exact nature) of the statistical transformations for this case is unclear in [8]. Consequently, the implemented prediction techniques are polynomial approximation and the GRNN.

As for *Case III*, each indicator has been predicted independently, and the absolute differences between the obtained results and the data given in [8], as well as the average, maximum, minimum and sum of absolute differences have been subsequently calculated (Table V).

TABLE V
ABSOLUTE DIFFERENCES OF CASE III

Case III	Optimal Technique	average	min	max	std
Urban Particulates	GRNN	0.541	0.000	12.025	1.305
Indoor Air Pollution	1st Degree Polynom	0.000	0.000	0.000	0.000
Drinking Water	GRNN	0.440	0.000	12.500	1.152
Adequate Sanitation	GRNN	0.532	0.000	12.200	1.314
Child Mortality	GRNN	0.621	0.000	12.450	1.110
Regional Ozone	5th Degree Polynom	0.247	0.012	2.139	0.361
Nitrogen Loading	5th Degree Polynom	0.184	0.000	4.998	0.500
Water Consumption	4th Degree Polynom	0.301	0.008	6.658	0.686
Wilderness Protection	1st Degree Polynom	0.027	0.000	0.052	0.015
Ecoregion Protection	5th Degree Polynom	0.187	0.000	0.601	0.164
Timber Harvest Rate	GRNN	1.433	0.000	28.433	3.566
Overfishing	GRNN	0.000	0.000	0.000	0.000
Agricultural Subsidies	GRNN	1.693	0.000	12.500	2.519
Energy Efficiency	GRNN	0.571	0.000	12.500	1.355
Renewable Energy	5th Degree Polynom	0.242	0.001	24.035	2.084
C02 per GDP	4th Degree Polynom	0.762	0.001	6.697	1.199

It becomes clear from the results that there is no single prediction technique that can be used for consistently deriving the proximity-to target data from the indicators. Only for two out of the sixteen indicators does the first degree polynomial constitute the the most consistent technique; the fourth and fifth degree polynomial provide the most accurate approximation for another two and four indicators, respectively, while – finally – the GRNN constitutes the most consistent prediction technique for the remaining eight indicators. These findings are not what would be expected as they clearly contradict what is stated in [8], namely that all the indicators have been statistically transformed in a uniform manner.

Case IV. From Raw Data Directly to the EPI

For the final case, an attempt has been made to predict the EPI directly from the raw data (indicators). The first degree polynomial not only gives acceptable results (the polynomials of higher degrees produce invalid results in the form of negative values), but is also superior even to the GRNNs. It is surprising that, although – as stated in [8] – the raw data has been subjected to various numerical and statistical transformations, a first degree polynomial is capable of predicting the EPI.

TABLE VI
ABSOLUTE DIFFERENCES OF CASE IV

Case IV	average	min	max	std	sum
1st Degree Polynomial	1.998	0.005	12.462	1.979	265.788
GRNN scaled	3.851	0.070	19.126	3.574	512.134

The numerical results are shown in Table VI, tabulating the absolute differences between the two most accurate techniques and the EPI values of [8].

B. Attempting to Reproduce the Pilot EPI 2006

The second part of this investigation attempts to reproduce the Pilot EPI 2006. The following three reproduction "paths" have been investigated, each employing different steps and distinct prediction techniques:

(a) EPI 1: the proximity-to-target data given in [5][3] is used directly on the coefficients given by the Report Method for calculating the policy categories. As the second (and final) step, the Report Methodology is used once more in order to produce the EPI value of the 133 countries.

(b) EPI 2: the raw data given in [5] constitutes the input, with, the optimal technique of Section III.*A.* (shown in the second column of Table V, and independently for each indicator) used for calculating the proximity-to-target-data. Subsequently, the optimal technique (again described in Section III.*A.* and shown in the second column of Table IV, independently for each policy category) is used for the evaluation of the policy categories, directly inputting the just evaluated proximity-to-target-data (rather than the values given in [8]). Finally, the calculated policy categories are transformed to EPI 2 using the optimal methodology (namely the 1st degree polynomial) described in Section III.*A*.

(c) EPI 3: the raw data given in the [8] are input in the 1st degree polynomial described in Section III.*A.* and EPI 3 is calculated directly using the 1st degree polynomial described in *Case IV* of Section III.*A*.

[3] The reason that the proximity-to-target-data constitutes the starting point in this case is that (as already mentioned) the description of the methodology leading to the EPI from the raw data is unclear [8].

ISBN: 978-1-61804-255-2

The absolute differences between the EPI values calculated for each of the three reproduction “paths” and the EPI values of [8] have been used for investigating the accuracy and consistency of EPI reproduction.

TABLE VII
ABSOLUTE DIFFERENCES OF EPIS

	average	min	max	std	sum
EPI 1	0,602	0,002	3,505	1,043	80,061
EPI 2	0,791	0,001	3,013	0,623	105,234
EPI 3	1,998	0,005	12,462	1,979	265,788

As shown in Table VII, the optimal reproduction “path” is (as expected) EPI 1, namely starting with the proximity-to-target data (rather than the indicators, thus skipping one step) and employing the weights given in [8]for producing the EPI values. EPI 1 is closely followed by EPI 2, a finding that is not only justifiable, but also quite interesting, since EPI 2 not only includes the extra step of transforming the indicators to proximity-to-target data, but also uses the optimal methodologies appearing in Tables III through to V (instead of the weights given in [5]) for approximating each stage of evaluating the Pilot EPI 2006. Finally, EPI 3 is clearly inferior to both EPI1 and EPI 2, suggesting that no clear relationship exists between the indicators (raw data) and the EPI values, i.e. that it is surprisingly not possible to calculate the Pilot EPI 2006 directly from the raw data using a free-form approximation.

TABLE VIII
POSITION DIFFERENCES IN EPI I

Position Difference	Number of Countries/Territories	Percentage
0 positions	45	33.83%
1 position	41	30.83%
2 positions	14	10.53%
3 positions	13	9.77%
4 positions	4	3.01%
5 positions	7	5.26%
6 positions	5	3.76%
7 positions	2	1.50%
8 positions	1	0.75%
11 positions	1	0.75%
SUM	133	100.00%

C. The Consistency of Ranking Participating Countries Using the Pilot EPI 2006

The differences in the rankings of the 133 participating countries have also been evaluated. The results are shown in Figures II through to IV, and tabulated in Table VIII, further confirming the superiority of EPI 1 at predicting as well as preserving the ranks of the 133 participating countries, with the next best being EPI 2; EPI 3 remains clearly inferior. Although such a result is expected; what is surprising is the

FIGURE II
DIFFERENCES IN EPI RANKINGS FOR EPI 1

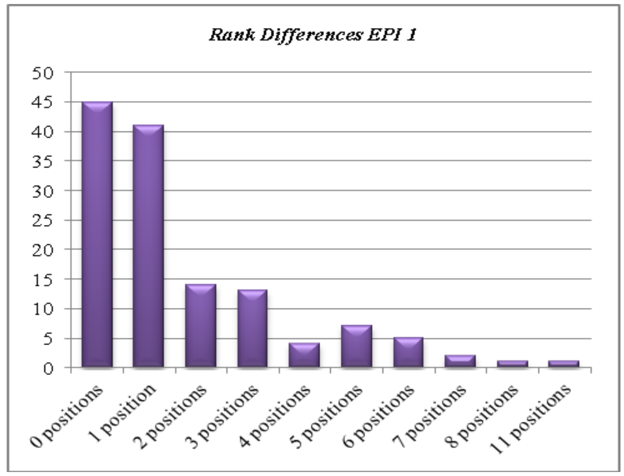


FIGURE III
DIFFERENCES IN EPI RANKINGS FOR EPI 1

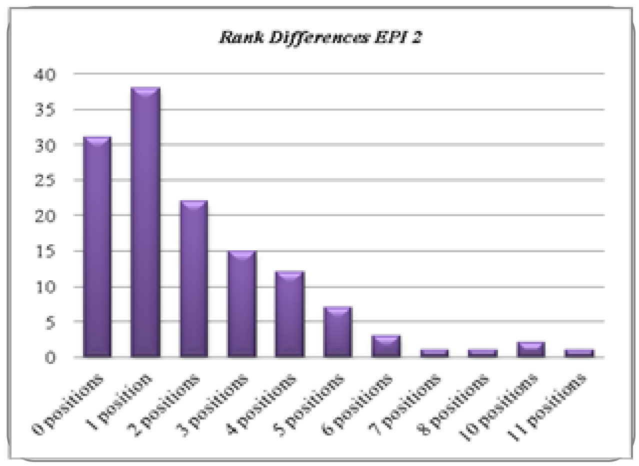
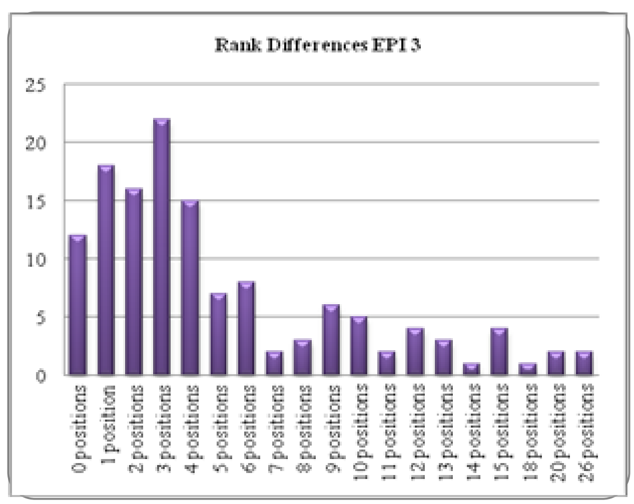


FIGURE IV
DIFFERENCES IN EPI RANKINGS FOR EPI 3



abundance of differences in rank for EPI 1. This can be explained by the assumption that even small numerical differences in the EPI values can cause significant differences in the ranking of the 133 countries, thus further suggesting that the Pilot EPI 2006 is highly sensitive to exact input values and polynomial coefficients.

IV. Conclusion

An initial investigation concerning the verification and reproduction of the EPI 2006 has left unanswered questions. The most important among them are:

- Why is it not consistently possible to use a first-degree polynomial for predicting the policy categories as well as the EPI (as supported in [8])?
- Why can the apparently complex conversion of the indicators to proximity-to-target data be most accurately approximated by a first degree polynomial, as can the direct conversion from indicators to EPI value?
- Why are the EPI values produced by the optimal techniques used for reproducing the process followed in [8] not sufficiently accurate in predicting the EPI values or in preserving the ranking of the 133 participating countries?

Concerning the implemented techniques, the GRNN constitutes the second-best prediction tool for deriving the Pilot EPI 2006 from the indicators, while it is also found the most consistent tool for predicting eight out of the sixteen proximity-to-target data from the indicators, as well as one policy category from the proximity-to-target data.

Finally, it is clear that further investigation is needed for implementing a unified methodology that can duplicate the step-by-step transition from one the stage of the methodology to the next. However, some light has been shed to the strengths and weaknesses of the alternative prediction methodologies.

References

[1] International Institute for Sustainable Development, "*The Sustainable Development Timeline*", 7th edition, 2012

[2] R. W. Kates et al. (2005), "*What Is Sustainable Development? Goals, Indicators, Values And Practice*", Science and Policy for Sustainable Development, Volume 47, Number 3

[3] UNEP (2002) "*Global Environment Outlook 3: Past, present and future perspectives*", Earthscan Publications Ltd, London - Sterling, VA

[4] UN (2002) "*Report of the World Summit on Sustainable Development*", Johannesburg, South Africa

[5] UN (2012) "*Report of the United Nations Conference on Sustainable Development*", Rio de Janeiro, Brazil

[6] Thomas M. Parris – Robert W. Kates "*Characterizing And Measuring Sustainable Development*" July 2003

[7] Ian Challenger, "*A Process For Developing Sustainability Indicator Sets*", July 2013

[8] Yale Center for Environmental Law & Policy, Center for International Earth Science Information Network (CIESIN) "*Pilot 2006 Environmental Performance Index*", 2006

[9] D.C. Esty, M. Levy, T. Srebotnjak, and A. de Sherbinin *2005 Environmental Sustainability Index: Benchmarking National Environmental Stewardship*, New Haven: Yale Center for Environmental Law & Policy, 2005

[10] P. A. Devijver and J. Kittler, *Pattern Recognition: a Statistical Approach*, Prentice-Hall, London, 1982

[11] C.R. Rao, H. Toutenburg, A. Fieger, C. Heumann, T. Nittner and S. Scheid, *"Linear Models: Least Squares and Alternatives (2nd Edition)"*, Springer-Verlag Series in Statistics, New York, U.S.A., 1999

[12] D.F. Specht, "*A General Regression Neural Network*". IEEE Transactions on Neural Networks, vol. 2, pp. 568-576, 1991

[13] D.F. Specht, "*Probabilistic Neural Networks and the Polynomial Adaline as Complementary Techniques to Classification*". IEEE Transactions on Neural Networks, vol. 1, pp. 111-121, 1990

[14] S. Arlot and A. Celisse "A survey of cross-validation procedures for model selection", Statistics SurveysVol. 4 (2010) 40–79, 2009

[15] The MathWorks 2009. R2009a MatLab & Simulink

Carbon Neutrality in University Campuses

Ayça Tokuç[1], and Gülden Köktürk[2]

***Abstract*—** Each year more carbon is being released into the atmosphere from the built environment. The business as usual lifestyle is dependent on carbon however some alternate policies and initiatives for a different way of life also emerged. One such significant concept is carbon neutrality and a way of integrating such a way of life into community is carbon-neutral campuses. Universities have the basic functions of education and research, however campuses are mini communities with economic and social responsibility. The aim of this paper is to determine principles for betterment of large campuses, towards carbon neutrality and environmental consciousness. It is possible to take various measures for carbon reduction therefore the question on how to incorporate more carbon neutral campuses into life can better be answered by a thorough study of examples. This study examines the principles, achievements and measures of carbon neutral campuses, as well as the ideal of a carbon neutral campus. In this context, three selected campuses from around the world with varying points of view towards carbon neutrality are studied. These campuses have top down and bottom up approaches as well as variance in how much precedence they give to new technologies or management. As a result, lessons learned from these studies are given.

***Keywords*—**Campus, carbon emissions, carbon neutrality, case study.

I. INTRODUCTION

AT the moment, the human civilization is facing one of his greatest challenges: the disruption in the stability of the climate. This challenge is causing worldwide problems in many areas including social, economic, environmental, and public health. Despite all the effort to balance this instability, many living systems in the world are continuing to decline. The cause of this current unhealthy, inequitable and unsustainable path is the cultural operation of modern society. Since the business as usual lifestyle is dependent on carbon, each year more carbon is being released into the atmosphere from the built environment.

However as attributed to Einstein, "The significant problems we face cannot be solved at the same level of thinking we were at when we created." [1]. Therefore we need to transform the way we think and act to achieve the results we want. Fortunately, some alternative policies and initiatives for a different way of life have also emerged. One such significant concept is carbon neutrality. Carbon neutrality is generally defined reducing or offsetting a building's carbon footprint [2]. Carbon neutrality is a significant input that shows the environmental impact of a city, a region, or a building. Therefore carbon neutral built environments contribute to both increasing social consciousness and betterment of the natural environmental systems. They are a necessary element of the cultural shift desired to increase social consciousness by example, for both environmental protection and decreasing global warming.

Higher education institutions have the potential to lead the aforementioned cultural shift since their basic functions include education as well as contribution to science and technology with new research [3], [4]. Universities educate and prepare most of the professionals who become a part of the society's institutions. With high visibility and impact potential through both their students and industry partnerships, universities can also become showcases for their research and innovations. In addition, with diverse citizens, environment, old and new buildings, infrastructure, travel, public health, and economic aspects, they are mini communities, where a carbon neutral life can be both taught and implemented, in other words lived. Even though the current educational system is reinforcing the current unsustainable lifestyle, production of new knowledge on sustainability is the social responsibility of universities [5]-[6].

Fortunately there are significant efforts in higher education institutions to accelerate its ability to meet in creation of a more sustainable future. The scale and speed of this shift requires many layers of specialized focus. This paper aims to examine the ideal of a carbon neutral campus by studying best practice. Three campuses with differing views toward carbon and its management were selected for a detailed examination. This paper examines the starting points, principles, roadmaps, achievements, and measures of these universities that strive to reach carbon neutrality. It also reports lessons learned from this examination.

II. CARBON NEUTRALITY IN CAMPUSES

To reach the goal of a carbon neutral campus, the most important steps are **identification** of a campus' carbon emissions, creation of a **roadmap**, and **reduction and neutralization** of carbon emissions.

Identification is the phase, in which the carbon footprint of a campus is calculated. Calculation of a baseline carbon footprint gives a campus the opportunity to identify and devise effective reduction and mitigation strategies. Global standards

[1] A. Tokuç is with the Architecture Department, University of Dokuz Eylül, İzmir 35160 Turkey (90-232-3018389; fax: 90-232-4532986; e-mail: ayca.tokuc@deu.edu.tr).

[2] G. Köktürk is with the Electrical and Electronics Engineering Department, University of Dokuz Eylül, İzmir 35160 Turkey (90-232-3017165; fax: 90-232-4531085; e-mail: gulden.kokturk@deu.edu.tr).

for calculating a carbon footprint guarantee that the results of carbon footprints calculated around the globe are comparable in a certain context [7]. The Greenhouse Gas (GHG) Protocol is the most common standard, however it only covers reporting of GHG emissions by the Kyoto Protocol, when necessary other emissions can be reported separately. According to GHG Protocol, all GHG emissions are classified under three scopes:

1) *Direct GHG emissions* that occur from sources that are owned or controlled by the institution, such as boilers, furnaces, vehicles etc.
2) *Electricity indirect GHG emissions* from the generation of purchased electricity. They are upstream activities that physically occur at the facility where electricity is generated.
3) All the *other indirect GHG emissions* which are a consequence of the activities of the organization, but occur from sources not owned or controlled by the organization. These include both upstream activities such as employee commuting and waste generated in operations as well as downstream activities, such as emissions from the production and transportation of purchased goods including life cycle emissions of goods [8].

Raw data of activities that produce carbon emissions can be gathered at the engineering office, financial office etc. Later, raw data is converted into carbon emissions using emission factors. The commonly used emission factors are taken from Intergovernmental Panel on Climate Change (IPCC) reports to calculate the 100-year global warming potential (GWP). In this stage, ideally all sources need to be taken into account, including sinks, and storage in the system [9]. However, there are various calculation methods and usually only some of the scopes are taken into account.

The next step is determining targets, a carbon budget, and creating an action plan, and relevant organization-wide policies such as sustainability, energy, waste, maintenance, travel, etc. This is the *roadmap*. It is a strategic document, which both shows the commitment of the institution to reach zero carbon in a certain amount of time and lists the strategies that the institution would use to decrease emissions. At its creation, a SWOT (Strengths/Weaknesses/Opportunities/ Threats) analysis would be beneficial to find a path in accordance with the organization's mission statement since there are various measures can be taken to decrease the carbon footprint. Each measure requires careful consideration and feasibility study. The roadmap also needs careful maintenance to keep on track -by constant feedback from data feedback.

The *reduction and neutralization* phase involves the implementation of the program. There are various campuses that aim to be carbon neutral, however since there are many variations in the outlook and involvement of the administration and the various stakeholders, while some institutions rely more on administrative approaches, some try to reach and involve as many stakeholders as possible usually at the starting point of the movement. Various measures can be implemented in many scales and while some campuses give precedence over technology, some rely on management. The question on how to incorporate more carbon neutral campuses into life can better be answered by a thorough study of examples.

III. Case Studies

The case studies here are chosen to represent differing points of view towards carbon neutrality. The first case is Plymouth University, UK, which had outside incentive in the form of governmental policy and targets. The second case is Arizona State University (ASU), USA, which made an internal decision by president of the university. At last, the third case is China Europe International Business School (CEIBS), China, in which the movement was led by its students who wanted to implement carbon neutrality. Thus they show various ways to deal with the concept.

A. Plymouth University, UK

The Climate Change Act 2008 (of the Parliament of the UK) requires that the carbon emissions from the six Kyoto GHG would be at least 80% lower than the 1990 baseline in the UK by 2050. It also proposes an interim target of 34% cut in emissions by 2020. Thus the Higher Education Funding Council for England (HEFCE) created a roadmap in parallel with UK's goals, and it encourages higher education institutions to adopt targets similar to HEFCE's national carbon strategy [10]. The Council also cooperates with many projects throughout the country.

Plymouth University is a Public University in the southwest of England. It has six campuses, with a main one that serves over 20,000 students. The University's energy use was controlled since it first installed an automated building management system in 1994, controlling almost 95% of all the campus buildings. It had an energy and water policy that has been kept up to date since 1996. Plymouth also accounted for and traded in the UK Emissions Trading Scheme in 2002. In addition it had an environmental policy since 2004.However the HEFCE encouragement was the point of origin for Plymouth's Carbon Reduction Plan.

The base year is 2005 and data from the building energy management system and utility bills for electricity, oil, and gas are considered in the calculation of carbon. The carbon baseline is 12,293 metric ton carbon dioxide equivalent ($MTCO_2e$) in 2005, its distribution can be seen in Fig.1 [11]. Because the UK Climate Change Act requires only Scope 1 and 2 emissions, the University's target also only considers them. Since there was no base data for fleet, commuting, business travel, waste and supply chain, the university measured new data and set 2010 as baseline for these items. Data collection for Scope 3 emissions is still going on however there is no baseline year at the moment. Table I shows the yearly available emission data according to Scopes [12].

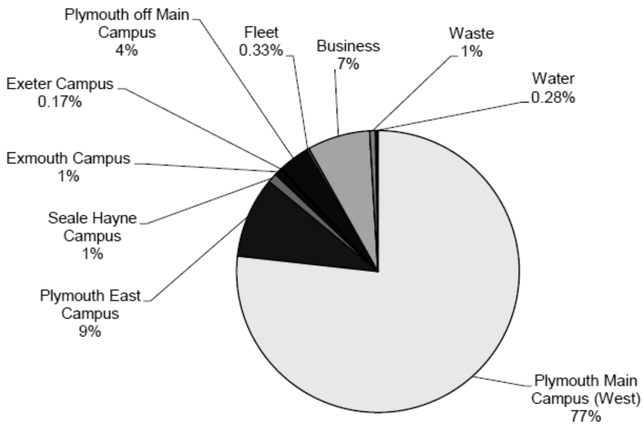


Fig.1 distribution of carbon emissions in Plymouth University 2005

Table I. Emission source of Plymouth University

	Type	*2005/06*	*2009/10*	*2011/12*	*2012/13*
Scope 1	CHP	NA	NA	NA	*Included*
	Solid fuel	NA	NA	NA	*Included*
	Liquid fuel	*Included*	*Included*	NA	NA
	Gaseous fuel	*Included*	*Included*	*Included*	*Included*
	Vehicle fleet	Data not available	*Included*	*Included*	*Included*
	Refrigerant gas	Data not available	Data not available	*Included*	*Included*
Scope 2	Grid electricity	*Included*	*Included*	*Included*	*Included*
	Heat purchased	NA	NA	NA	*Included*
Scope 3	Employee commuting	Data not available	Data not available	*Included*	*Included*
	Business travel	Data not available	*Included*	*Included*	*Included*
	Procurement	Data not available	Data not available	*Included*	*Included*
	Student Commuting	Data not available	Data not available	*Included*	*Included*
	Other (waste)	Data not available	*Included*	*Included*	*Included*
	Other (water)	Data not available	*Included*	*Included*	*Included*

NA: Not Applicable

The carbon management plan of Plymouth University was a roadmap to being carbon neutral by 2030, with a 28% emission reduction target by 2015. While the initial reduction rates were the same as HEFCE's, Plymouth continuously updated its targets to keep them current. Table II shows the 2013 update of target emission reduction goals against the 2005 baseline.

Table II. Target emission reductions of Plymouth University ($MTCO_2e$)

Baseline Year	*Current Emissions*	*Targets against 2005 Baseline Year*		
2005	2012	2015	2020	2030
12,645	10,463	8,558 -32% of baseline	7,207 -43% of baseline	6,040 -52% of baseline

The strategic approaches to achieve the carbon neutrality goals are:

1) Energy usage in buildings and equipment will be reduced.
2) Alternative and renewable energy sources will be used.
3) Emissions associated with waste and procurement will be reduced.
4) Emissions associated with travelling and vehicles will be reduced.
5) Policies and strategies for carbon management will be created.
6) Key stakeholders, including all staff, students, and visitors will be communicated with and involved in order to develop and implement the carbon management plan.
7) Awareness-raising initiatives and guidance will be ensured for the stakeholders.
8) Environmental communication with stakeholders will be increased and encouraged [12].

Various major and minor projects were implemented in the campus according to the Plymouth Carbon Reduction Plan. According to the University of Plymouth Carbon Management Plan 2010-2015 2013 update, the carbon savings from baseline are 2,805 MTCO2e. Their breakup is given in Table III [12].

Table III. 2012 Carbon savings against the 2005 baseline [12]

Carbon Saving Category	*$MTCO_2e$*	*%*
Energy Efficiency Projects	672	24
Fuel Conservations	401	14
Improving Space Utilization	348	13
Behavior Change	1161	41
RGF Completed 2009	149	5
RGF Completed 2010	73	3

It is perhaps surprising to see that most of the contribution was gained from behavior change. Although not costly by itself, the constant education to both the students and staff is has begun to pay off. On the one hand while some projects have only one or two years of investment return period but huge impacts on carbon emissions, it is worthy of note that these projects would not have been implemented if there was no carbon reduction plan. On the other hand, one of the most costly measures taken in Plymouth University is the combined heat and power (CHP) system for the main campus, which is responsible for reducing 10% of the emissions by itself.

B. Arizona State University, USA

Although the USA does not have a carbon reduction plan apart from coal powered power stations, many of the higher education institutions in the USA have one since 2006. The American College and University President's Climate Commitment provides a framework to implement plans in pursuit of climate neutrality. By signing the commitment, the institutions aggree to:

1) complete an emissions inventory,
2) within two years, set a target date and interim milestones for becoming climate neutral,
3) take immediate steps to reduce GHG emissions by choosing from a list of short-term actions,
4) integrate sustainability into the curriculum and make it part of the educational experience, and

5) make the action plan, inventory and progress reports publicly available [13].

Arizona State University (ASU) is a public metropolitan research university with four campuses, and around 60,000 students at its Tempe campus. Even before making any commitment to become carbon neutral, ASU had taken a lot of measures to increase energy and resurce efficiency. All of its constructions had US Green Building Council’s LEED Silver standard or equivalent. In addition, its appliance purchasing policy required certification of energy efficiency.

ASU has signed the aforementioned climate agreement in 2006 and has taken its baseline emissions data for fiscal year 2007 (FY07), with a total of 308,226 $MTCO_2e$. The FY07 emissions is given in Fig.2.

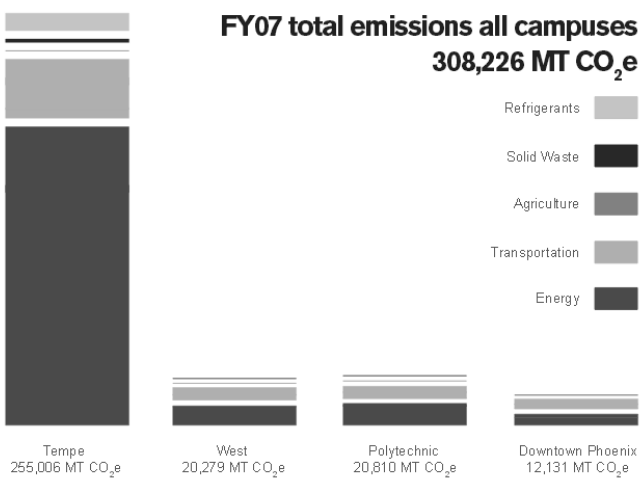


Fig. 2 distribution of carbon emissions in Arizona State University

ASU aims to become carbon neutral by 2025 for all areas except transportation, for which the target year is 2035. The ASU roadmap has 3 term plams to reach carbon neutral: 1. near term, of immediate five years, 2007-2011, 2. middle term, of six to eleven years, 2012–2017, and 3. long term, of twelve to nineteen yars 2018–2025. Fig.3 shows the target emission decreases of the ASU Carbon Neutrality Action Plan [14].

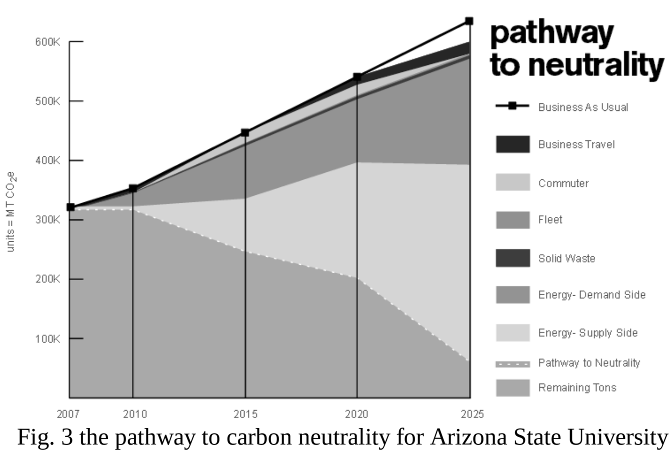


Fig. 3 the pathway to carbon neutrality for Arizona State University

The roadmap of ASU to reach carbon neutrality by 2025 includes:

1) establishment of a policy to offset all GHG emissions generated by air travel to be paid by ASU. The money will be used to create a fund to support carbon reduction projects till 2035,
2) encouragement and provision of access to public transportation for all faculty members,
3) generation of at least 15% of yearly electricity consumption from renewable sources within one year of signing the commitment, and
4) establishment of a policy or a committee that supports climate.

Energy use accounted for 75% of ASU’s baseline GHG emissions, therefore it was the primary target of carbon reduction projects. The most visible change in the university campus is energy generation with solar panels. For this aim, 89 solar systems that generate 24.1 MW equivalent energy were installed in 2014. Although this impressive number is ahead of schedule and has reached the end of 2015 target, it is by no means the outcome of renewable energy projects on campus.

C. China Europe International Business School, China

Currently China is the top GHG emitter in the World. China released 29% of the global total emissions in 2013 [15]. Although China has set its first carbon target in 2009, its GHG emissions has continued to grow. In addition, before 2014 there was no plan to put any sort of cap on its carbon emissions. Controversially since there are so many opportunities to reduce carbon emissions in China, China has created many projects that sell carbon credits.

China Europe International Business School (CEIBS) is a graduate school for business related topics. It serves around 1,000 graduates in its 3 campuses. Its main campus is in Shanghai. Although the school has no previous record of being carbon conscious, its students learn a lot about carbon management in the curricula as future business leaders.

Five MBA students for the class of 2010 set their target as being the first carbon neutral business school in 2010. They calculated their campus’ carbon footprint with help from their faculty. As mentioned above they had lots of taught skills from business strategy to project management and therefore could formulate a roadmap. They dubbed themselves “The Decarbonators” and their roadmap “the Carbon Neutral Project” [16]. Their project had a definite timeline of being carbon neutral within one year. It required the students to create their business strategy to reduce emissions, and offset the remaining from carbon market purchases, however in the upcoming years the Decarbonators would also continue the projects from the previous years.

The group reached their target in 2010 with help from planting 1,000 trees within a Project in Inner Mongolia. The Project in Mongolia was planting a forest to fight against the expanding desertification, as well as building capacity in the natives of the region, who would later continue to look after the forest. In addition, the non-governmental organization (NGO) that led the event ensured scientific data on the amount of carbon absorption by these trees. One tree would absorb

0.25 $MTCO_2e$ during its 15-20 year lifetime, thus 1,000 trees would offset 250 $MTCO_2e$ emissions. The students traveled to Mongolia and planted the trees themselves [17].

In 2011, the CEIBS administration announced its intention to be fully carbon neutral and has actively supported the Decarbonators [18]. A competition was held to select the new Decarbonators between four groups of students. The winning group continued the Projects from the year before and looked at new carbon reduction alternatives. They concentrated more on HVAC systems in buildings and renewable energy integration to their campus, with possible implementation for the new campus under construction. In 2011, the campus completed and put into service new buildings yet they also had to plant only 1,000 trees to offset their remaining carbon emissions, thus CEIBS was carbon neutral for another year [17].

IV. LESSONS LEARNED

There are many interpretations of the term **"carbon neutral"** and it is open to exploitation just like the term **"sustainability"**. Therefore caution is necessary in dealing with the concept of carbon neutrality. If there is no determination of carbon footprint or the process goes from identification to neutralization without any means of reduction, i.e. no carbon management strategy, no clear cut targets or date set, then it is highly likely that there is greenwashing involved.

Although data and a plan are essential to reach the carbon neutrality goal, in a large and diverse environment such as a university campus, there is no right or better way. Thus the best practice is leading by example. Yet the university needs commitment to reaching zero carbon, since without the will, the best data and plans cannot be of any help.

There exist some projects that need little investment yet have big impacts. These small victories keep the environmental morale high and lead to bigger projects, thus making significant boosts in reaching the target. Discovering these noteworthy projects require asking the right questions and diligent planning.

However the last few percentages are harder to obtain and require majör projects and the first major project is the most difficult to realize. Heavy coordination with the utility companies is necessary. The companies are stakeholders with much knowhow, experience, and resources in implementation of various strategies that deal with renewable or more efficient energy generation technologies.

Emissions reductions should be applied through long-term strategies. The financing options for big projects such as CHP and solar energy projects need to be thoroughly and carefully explored. Since the use of renewable energy credits and verifiable carbon offsets in meeting the carbon neutrality goals require continuous effort, they should be meticulously deliberated before implementation.

REFERENCES

[1] Second nature and United States green building council, *Advancing Education for Sustainability: Teaching the Concept of Sustainable Buildings to All Students*. Strategy paper, July 2010, p 5.

[2] J. Zuo, B. Read, S. Pullen, and Q. Shi, "Achieving carbon neutrality in commercial building developments – Perceptions of the construction industry" *Habitat International*, Vol. 36, Issue 2, April 2012, pp. 278–286.

[3] W. Calder, R. Clugston, "International Efforts to Promote Higher Education for Sustainable Development," in Planning for Higher Education, Journal of the Society for College and University Planning, Spring 2003.

[4] J. L. Elder, "Research and Solutions: Think Systemically, Act Cooperatively: The Key to Reaching a Tipping Point for the Sustainability Movement in Higher Education" *Sustainability: The Journal of Record*, Vol 1, Issue 5, 2008, pp.319-328.

[5] L. Wright, "Performıng Teachıng: In Search Of The Profound", Ph. D. thesis, Faculty of the Graduate School, Texas University, USA, 2002.

[6] T. S. Grindsted, T. Holm, "Thematic development of declarations on Sustainability in Higher Education", *Environmental Economics*, Vol. 3, Issue 1, 2012.

[7] S. L. Zhu, W. T. Wang, "Development of National Greenhouse Gas Emissions Inventories in the Context of International Climate Negotiations", *Advances in Clımate Change Research*, vol. 4, No. 1, 2013, pp. 60-68.

[8] World Business Council for Sustainable Development and World Resources Institute WRI/WBCSD, *The Greenhouse Gas Protocol A* Corporate Accounting and Reporting Standard Revised Edition, 2004.

[9] S. Solomon et al., "Climate Change 2007: The Physical Science Basis" Intergovernmental Panel on Climate Change, 2007.

[10] L. O. Meida, P. Brockway, K. Letten, J. Davies and P. Fleming, "Measuring Carbon Performance in a UK University through a Consumption-Based Carbon Footprint: De Montfort University Case Study". *Journal of Cleaner Production*, Vol. 56, 2011, pp. 185-198.

[11] "University of Plymouth Sustainability Strategy (2009-2014)" 14.08.2014. [Online]. Available: https://www1.plymouth.ac.uk/sustainability/environmentandsocialresponsibilities/Documents/Sustainability%20Strategy%202009-2014.pdf

[12] P. Lumley, "Plymouth Carbon Management Plan (2010-2015)" 14.08.2014. [Online]. Available: https://www1.plymouth.ac.uk/sustainability/environmentandsocialresponsibilities/Documents/Carbon%20Management%20Plan%202010-2015.pdf

[13] 21.08.2014. [Online]. Available: http://www.presidentsclimatecommitment.org/about/mission-history.

[14] C. Babbitt et all., "ASU carbon neutrality action plan" 14.08.2014. [Online]. Available: http://rs.acupcc.org/site_media/uploads/cap/261-cap_1.pdf.

[15] C. Le Quéré et all., "Global carbon budget 2013" *Earth System Science Data*, Vol. 6, 2014, pp. 235–263.

[16] A. Song, E. Seidner, and R. Seiler. "The Path to Carbon Neutrality Guide on How to Turn Business Schools Carbon Neutral", *Graduate Business Conference 2012*, New York, 2012, submitted for publication.

[17] L. Underwood, "The Decarbonators", *CEIBS Alumni Magazine*, Vol. 2, Cover story. 27.10.2014. [Online]. Available: http://www.ceibs.edu/link/latest/63683_11.shtml.

[18] "CEIBS Becomes 1st Business School in Asia to Achieve 'Carbon Neutral' Status" 27.10.2014. [Online]. Available: http://www.ceibs.edu/media/archive/62800.shtml.

Some aspects of assessment of environmental and human health effects of power transformer life cycle

Niculae N. Boteanu, and Florin Ravigan

Abstract—This paper goes on to enhance the way of thinking that technical activities cannot be separated from our natural environment existence on Earth, and within the present industrial world no biological ecosystem is free of anthropogenic influence. This study is focused in assessing some sustainability aspects of power transformers, regarding the life cycle assessment, as well as the environmental and human health impact. Power transformer, as main equipment used in the electrical transmission and distribution systems, must be analyzed in terms of efficiency and sustainability parameters, under the legislation and standards in use. This way a holistic approach of technical, health care, environmental and economic aspects may be highlighted. The paper focuses on the stage of reuse of a distribution power transformer, presenting the full and chopped lightning impulses of transformer tests in order to reintroduce the product in the electric networks and to continue its life cycle.

Keywords—Electric transformer and autotransformer, life cycle assessment, lightning impulse

I. Introduction

NOWADAYS the electric power is used all over the world, and human consider it as a main part of civilization [1-2].

For 100 years electricity has been used, offering great benefits to people, without society being aware of any adverse health effect, other than thermal injury and electrocution. One could note also that the environmental impact of using electrical and electronic equipment had been ignored.

Still, over the last decades authorities and professional organizations emphasized that and the generation, transmission, and use of electric energy is associated with the production of weak electric and magnetic fields (EMF) which oscillate 50 or 60 times per second (power-line frequency) [1-3]. Wherever electricity is generated, transmitted, or used, electric and magnetic fields (EMF) are created, due to the presence and motion of electric charges. The electric and magnetic fields are a fact of our daily life, since they are emitted by power lines, transformers, service wires, as well as by home appliances, such as computers, television, clocks, electric blankets, and so on [1-4].

Generally, these fields are time-varying vector quantities characterized by a number of parameters, including their frequency, phase, direction, and magnitude.

This paper goes on to enhance the way of thinking that technical activities cannot be separated from our natural environment existence on Earth, and within the present industrial world no biological ecosystem is free of anthropogenic influence [1,5]. This study is focused in assessing some sustainability aspects of power transformers, regarding the life cycle assessment, as well as the environmental and human health impact. Power transformer, as main equipment used in the electrical transmission and distribution systems, must be analyzed in terms of efficiency and sustainability parameters, under the legislation and standards in use. This way a holistic approach of technical, health care, environmental and economic aspects may be highlighted.

II. Life Cycle Assessment of Power Transformers

Life Cycle Assessment (LCA) is the most appropriate managerial instrument that offers a framework integrated to Cleaner Production and Industrial Ecology for analyzing a system, a product or an equipment from the extraction phase through the operation stage until the end of the product [1-5]. In an illustrative assertion, the full Life Cycle Assessment (LCA) is denoted as Cradle-to-grave, meaning from resource extraction - cradle to use phase and disposal phase grave, or in a new form as Cradle-to-cradle, in order to emphasize that anthropogenic activities should not be generated any waste, and the end of life of a product should mean the beginning of life of a new product [3-5].

In Figure1 it is presented the diagram of the LCA methodology and framework according to the source provided by ISO 14040:1997.

One could note that a complete LCA consists of the four steps that are interconnected, respectively: goal and scope definition; inventory analysis; impact assessment; interpretation.

Niculae Boteanu is with the University of Craiova, Faculty of Electrical Engineering, Romania,; e-mail: nboteanu@em.ucv.ro.

Florin Ravigan is with the University of Craiova, Faculty of Electrical Engineering, Romania,; e-mail: florin.ravigan@ie.ucv.ro.

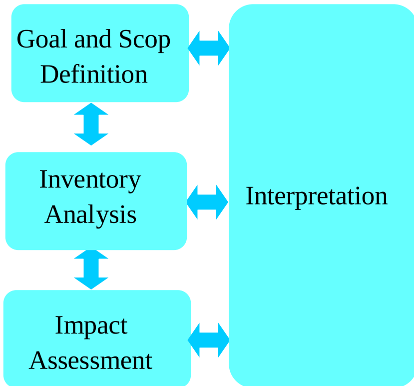


Fig.1. LCA Methodology according ISO 14040:1997

An important step of LCA is Life Cycle Inventory (LCI) analysis that entails creating an inventory representation of flows from and to nature for a product system. Inventory flows impose to represent the fluxes configuration of system inputs, such as water, energy, and raw materials, and the system outputs, represented by the final product and by the releases to air, land, and water [3-4].

Hence, to develop the Life Cycle Inventory, a flow model of the technical system is constructed using data on inputs and outputs. The flow model is typically illustrated with a flow chart that includes the activities that are going to be assessed in the relevant supply chain and gives a clear picture of the technical system boundaries. The input and output data needed for the construction of the model are collected for all activities within the system boundary, including from the supply chain (referred to as inputs from the techno-sphere). The data must be related to the functional unit defined in the goal and scope definition. Data can be presented in tables and some interpretations can be made already at this stage. The results of the inventory is an LCI which provides information about all inputs and outputs in the form of elementary flow to and from the environment from all the unit processes involved in the study [3-4].

Within LCA, the Inventory Analysis is followed by the Impact Assessment. This phase of LCA is aimed at evaluating the significance of potential environmental impacts based on the LCI flow results. One could note that classical life cycle impact assessment (LCIA) consists of the following mandatory elements [3-4]:

- selection of impact categories, category indicators, and characterization models;
- the classification stage, where the inventory parameters are sorted and assigned to specific impact categories; and
- impact measurement, where the categorized LCI flows are characterized, using one of many possible LCIA methodologies, into common equivalence units that are then summed to provide an overall impact category total.

In many LCAs, characterization concludes the LCIA analysis; this is also the last compulsory stage according to ISO 14044:2006.

Life Cycle Interpretation is a systematic technique to identify, quantify, check, and evaluate information from the results of the life cycle inventory and/or the life cycle impact assessment [3-4]. The results from the inventory analysis and impact assessment are summarized during the interpretation phase. The outcome of the interpretation phase is a set of conclusions and recommendations for the study. According to ISO 14040:2006, the interpretation should include:

- identification of significant issues based on the results of the LCI and LCIA phases of an LCA;
- evaluation of the study considering completeness, sensitivity and consistency checks; and
- conclusions, limitations and recommendations.

Consequently, over the last decades, harmonizing EU Directives impose the environmental impact assessment to be carried out for all phases of transformer life [3-4,6-8], according to Life Cycle Assessment tool: production phase, use phase, reuse phase and end-of-life phase.

III. Environmental and Human Health Impact of Power Transformer Use Phase

If The environmental impact of power transformers in the phase of use is mainly emphasized by the pollution caused by the electric and magnetic fields (EMF) [1-2,6-11].

An electromagnetic field is composed of two components, the electric and the magnetic fields. The electric field is created by the presence of an electric charge [2,6]. It describes the magnitude and direction of the force it exerts on a positive electric charge. The magnitude of the electric field depends on the difference in potential between charge-carrying bodies, including conductors, regardless of the amount of current that is flowing in them. In contrast, a magnetic field is created by the motion of electric charges. Typically, this motion is represented by a flow of charge in the form of an electric current, which gives the number of charges per second passing through the conductor. The magnetic field acts only on other electric charges in motion. Thus, a magnetic field is created by an electric current and describes the magnitude and direction of the force exerted on a nearby current (moving charges). The magnitude of the magnetic field is proportional to the current flow in a conductor, regardless of the voltage present.

Electromagnetic fields are present everywhere in universe even they are invisible to simple naked eye [2,6,10]. Hence, natural EMFs could occur where there is build up of electricity as during a thunderstorm. In fact, the electrical discharge are found at the origin of life on Earth. Nowadays humans must be careful in using electric and electronic equipment that are actually man made sources of EMFs. Everyone is exposed to EMfs on a daily basis, since the EMFs comes computers, TV, cell phones, home appliances, aircraft, overhead lines and electrical transformers [1-2,6-11].

In 1996 World Health Organization (WHO) established the International Electromagnetic Fields Project [11] to investigate potential health risks associated with technologies emitting EMF, and in 2005 the Task Group of scientific experts of WHO concluded a review of the health impacts of ELF electric and magnetic fields.

Following publication of WHO Environmental Health

Criteria Report on ELF fields [9], ICNIRP (International Commission on Non-Ionizing Radiation Protection) established international guidelines for limiting high-level exposure to time varying electric, magnetic and electromagnetic fields [10].

It is very important to emphasize that the World Health Organization carried out the key points regarding the links between Electromagnetic Fields and Public Health [11]:

- The electromagnetic spectrum encompasses both natural and human-made sources of electromagnetic fields.
- Frequency and wavelength characterize an electromagnetic field. In an electromagnetic wave, these two characteristics are directly related to each other: the higher the frequency the shorter the wavelength.
- Ionizing radiation such as X-ray and gamma-rays consists of photons which carry sufficient energy to break molecular bonds. Photons of electromagnetic waves at power and radio frequencies have much lower energy that do not have this ability.
- Electric fields exist whenever charge is present and are measured in volts per meter (V/m). Magnetic fields arise from current flow. Their flux densities are measured in microtesla (μT) or millitesla (mT).
- At radio and microwave frequencies, electric and magnetic fields are considered together as the two components of an electromagnetic wave. Power density, measured in watts per square meter (W/m^2), describes the intensity of these fields.
- Low frequency and high frequency electromagnetic waves affect the human body in different ways.
- Electrical power supplies and appliances are the most common sources of low frequency electric and magnetic fields in our living environment. Everyday sources of radiofrequency electromagnetic fields are telecommunications, broadcasting antennas and microwave ovens.

Exposure to electromagnetic fields is not a new phenol-menon. However, during the 20th century, environmental exposure to man-made electromagnetic fields has been steadily increasing as growing electricity demand, ever-advancing technologies and changes in social behavior have created more and more artificial sources [2]. Everyone is exposed to a complex mix of weak electric and magnetic fields, both at home and at work, from the generation and transmission of electricity, domestic appliances and industrial equipment, to telecommunications and broadcasting.

It is not disputed that electromagnetic fields above certain levels can trigger biological effects. Experiments with healthy volunteers indicate that short-term exposure at the levels present in the environment or in the home do not cause any apparent detrimental effects. Exposures to higher levels that might be harmful are restricted by national and international guidelines. The current debate is centered on whether long-term low level exposure can evoke biological responses and influence people's well being.

Yet, despite a multitude of studies, there remains considerable debate over what, if any, health effects result from exposure to EMF [1-2,9-11]. There is still no clear answer to the question if the exposure to electric and magnetic fields resulting from the production, distribution, and use of electricity promote cancer or initiate other health problems.

The challenge for exposure assessment is to choose a summary measure that is physically meaningful and biologically relevant [2].

For the most part, researchers have focused on ELF magnetic fields resulting from power lines, appliances, and occupational exposures.

In the broader context of human exposures and epidemiological studies, it should be remembered that typical exposures to EMF occur over a wide range of frequencies and in conjunction with static fields [2,6-8].

The discussion in this paper and many other research studies approach primarily on magnetic fields but could include electric fields when possible because of their inherently close association with electric power systems. Voltage and current determine the magnitude of the electric and the magnetic fields at a location, respectively, with the source geometry and distance from the source to the measurement location. The strength of an electric field is usually measured in volts per meter (V/m) or sometimes in kilovolts per meter (1 kV/m = 1000 V/m). Magnetic fields can be designated by either magnetic flux density (B) or magnetic field strength (H); both are proportional to the magnitude of the current. One could note that the magnetic flux density is denoted also as magnetic induction B that is measured in the centimeter-gram-second unit, the gauss (G), or the unit of the International System (IS), the tesla (T); 1 mG = 1 x 10^{-3} G = 0.1 μT. The magnetic field strength H is measured in SI units of amperes/meter (A/m). B and H are related through the equation: $B = \mu H$, where μ0 is the magnetic permeability of a vacuum. To a close approximation, μ0 remains the same for air and body tissues, and only one of the variables, B or H, need be measured. EMF can be arranged in an orderly fashion in an electromagnetic spectrum, according to their frequency (f) or wavelength (Ü), where Ü = c/f and c is the velocity of light. The magnetic permeability (μ) of living tissue (with very few, localized exceptions) is practically equal to that of free space. Consequently, the magnetic flux density inside the body is nearly equal to that outside. One could note that a 60 Hz field of 100 μT oriented along the head-to-feet axis of a human, with an average radius of 15 cm, will induce near the periphery of the body an average electric field of 2.8 x 10^{-3} V/m. These magnetically induced internal electric fields are very much larger than those due to a 100^{-3}V/m external electric field in air. A 100-V/m electric field represents the upper limit of those found in typical homes; however, induced electric fields are still much smaller than internal electric fields associated with nerve and muscle stimulation. The average electric field induced by a 0.3 T 60 Hz field near the surface of a human with a 15 cm radius is only 8.5 x 10^{-6} V/m. Thus, typical magnetic fields encountered in epidemiological studies of residences induce internal currents and electric fields that are roughly one million times smaller than the currents required to produce acute nerve and muscle stimulation.

Despite many studies [5-7], the evidence for any effect remains highly controversial. However, it is clear that if electromagnetic fields do have an effect on cancer, then any increase in risk will be extremely small. The results to date contain many inconsistencies, but no large increases in risk have been found for any cancer in children or adults [2].

A number of epidemiological studies suggest small increases in risk of childhood leukemia with exposure to low frequency magnetic fields in the home. However, scientists have not generally concluded that these results indicate a cause-effect relation between exposure to the fields and disease (as opposed to artifacts in the study or effects unrelated to field exposure). In part, this conclusion has been reached because animal and laboratory studies fail to demonstrate any reproducible effects that are consistent with the hypothesis that fields cause or promote cancer. Large-scale studies are currently underway in several countries and may help resolve these issues [2,10-11].

The European Union recommend the ICNIRP guidelines, through the Recommendation of the Council of Health Ministers to limit public exposures to electromagnetic fields in Member States (EU, 1999) and through the Physical Agents Directive limiting occupational exposure to ELF EMF (EU, 2004).

The aim of these exposure guidelines, standards, recommendations and directives for ELF EMF is to avoid the situations in which electric fields and currents induced by external electromagnetic fields could create harmful health effects. Since high-voltage overhead line and power transformers create strong magnetic fields, major issues are concerning the high voltage substation workers and the distance at which people can consider themselves safe living in surroundings [3-11].

Although the science is far from conclusive, the existing research results are highly suggesting that an association between exposure to electromagnetic fields and the development of certain health problems could appear. Consequently, the need for continuous research arises, and a realistic risk assessment can be performed when approaching the electromagnetic fields caused by anthropogenic actions..

IV. Units Case Study. Distribution Transformer Testing for Reuse Phase of LCA.

In order to be reused, a failed transformer must be repaired and then submitted to specific tests. In this section there are presented the results of a transformer and an autotransformer testing according to IEC standards and EU legislation.

The most important efficiency parameters of transformers are no-load and load losses, which are responsible for the electricity losses during the use phase. These parameters are covered by different standards depending on the transformer type, the main being the IEC 60076-1, that is the general generic standard for power transformers with European equivalent EN 60076-1.

I. Hence, for the transformer that had failed during the use phase in the Romanian Energetic System, after repairing it, the compulsory tests for the transformer reuse were performed, as is shown in Fig. 2.

Fig.2 Regarding the transformer tests

a.The transformer TTU-DR, produced in 2009, with the terminals' connection Dy45, rated power PN=250kVA, rated voltage UN=20/04kV, and rated current IN=7.22/36A had been submitted to tests in order to be reuse within the Romanian Electric System after the repair process.

First step consisted in verifying the terminals' connection

Winding/Step	1	2
HV	21.000	20.000
LV	401	400.5

Table 1

Dy45 and the transformation ratios, as below in Table 1:

Further there were performed the tests according to IEC standards. Hence:

1. The parameters within the non-load test were: U0=20.000V, P0=7150 W, I0=0.1A, I0%=2.9%.

2. The load test was characterized by: I_N=360A, U_{sc0} = 1150V, $U_{sc\%}$ = 5.75%, the active power $P_{sc\Theta}$=14.325 W at the temperature Θ=30^{o}C.

3. The insulation resistance had been verified, resulting: $R_{HV\text{-}(LV+ground)}$ = 3300MΩ, at K_{abs}=1.47, $R_{LV\text{-}(HV+ground)}$ = 2970MΩ, at Kabs=1.38, at the oil temperature Θoil =26oC.

4. The ohmic resistances of transformer windings have been verified, resulting: $R_{HV/AB}$=21.76 Ω, 5. $R_{HV/BC}$=21.76 Ω, $R_{HV/AC}$=21.76 Ω, RLV/ab=0.443 mΩ, $R_{LV/bc}$=0.443 mΩ, $R_{LV/ac}$=0.442 mΩ, at a winding temperature Θ =24oC.

5. Test of applied voltage of 50kV fo1 minute between HV-(LV+ground) has been validated.

6. Test of applied voltage of 2700kV for1 minute between LV and ground has been validated.

7. Test of reduced applied voltage of 465V for 30 seconds on the LV winding, at 50Hz has been validated.

b.The transformer TTU-DR, with terminals'connection Dy05, P_N=630kVA, U_N=6/0,4kV, I_N=60,6/904A, had been submitted to tests in order to be reuse within the Romanian Electric System after the repair process.

Winding/Step	1	2	3
HV	6300	6000	5700
LV	400	400	400

Table 2

First step consisted in verifying the terminals' connection Dy45 and the transformation ratios, as below:

1. The parameters within the non-load test were: U_0=6.000V, P_0=12470 W, I_0=1.51A, $I_{0\%}$=0.91%.

2. The load test was characterized by: I_N=910 A, U_{sc0} = 342V, $U_{sc\%}$ = 5.7%.

3. The insulation resistance had been verified, resulting: $R_{HV-(LV+ground)}$ = 1795MΩ, at K_{abs}=1.81

RLV-(HV+ ground) = 2005MΩ, at Kabs=1,77, at the oil temperature Ɵoil =16oC.

4. The ohmic resistances of transformer windings have been verified, resulting: $R_{HV/AB}$=4.917Ω, $R_{HV/BC}$=4.918Ω, $R_{HV/AC}$=4.917 Ω, $R_{LV/ab}$=0.00773 mΩ, $R_{LV/bc}$=0.00771 mΩ, $R_{LV/ac}$=0.00773 mΩ, at the winding temperature Ɵ=17^{o}C.

5. Test of applied voltage of 22kV fo1 minute between HV-(LV+ground) has been validated.

6. Test of applied voltage of 2700kV for1 minute between LV and ground has been validated.

7. Test of reduced applied voltage of 460V for 60 seconds on the LV winding, at 50Hz has been validated.

II. Further in this paper there will presented the full and chopped lightning impulses of autotransformer tests from manufacturers that were investigated by method of graphically recording according to IEC 60060-1/1989, IEC 61083-2/1996 and IEC 60076-3/2000. In this case study the tested product was a three- phase autotransformer ATUS-OLAF 280/280/60 MVA; 400/157.5 / 30 kV; Connection YNa0d1

The technical characteristics established by manufacturer are:

- Rated power: OFAF 280 for HV / 280 for MV / 60 MVA for LV
- Rated voltage: 400 kV for HV; 157.5 kV for MV; 30 kV for LV
- Rated normal current: 404.1A for HV; 1026.1 A for MV; 1154.7 A for LV
- Rated frequency: 50 Hz

The reference standard is IEC 60076 – 3/ 2000, and the tests performed were for 1.2 /50 μs full wave lightning impulse test.

One could note that for the lightning impulse test for full wave 1.2 / 50 μs the atmospheric conditions were: p = 1001 mbar; t = 19.1^{o}C; hr = 60.7 %. the test standard: IEC 60076 – 3 / 2000, clause13, and the rated lightning impulse withstand

Tested terminal	Full wave (kV)	Wave- shape Full wave (μs)
x1+a3, x2, x3	250	0.84 ÷ 1.56 / 40 ÷ 60
Y1, Y2, Y3	750	0.84 ÷1.56 / 40 ÷ 60
Y0	450	0.84 ÷ 13 / 40 ÷ 60
H1, H2, H3	1425	0.84 ÷ 1.56 / 40 ÷ 60

Table 5

voltages as below:

The parameters of the impulse generator 4.2 MV no.5 – 1197 and of the used voltage divider were the following.

Tested terminal	Parameters of impulse generator			
	Stages number	Cs [μF]	Rs [Ω]	Rp [Ω]
x1+a3, x2, x3	2x4	1.152	25.9	460
Y1, Y2, Y3	5x2	0.2304	176.3	575
Y0	4x3	0.432	564	460
H1, H2, H3	10x1	0.0576	196	1380

Table 3

As an Addenda one could note that Cs is the equivalent capacity of impulse generator; Rs is equivalent serial resistance of impulse generator; and Rp is equivalent parallel resistance of impulse generator

The terminal connections of the tested autotransformer were as below, with the notes that:

- during the test, core, frame, tank and terminals of current transformers were connected to earth;
- during the tests the tap changer was on following position: Y0,Y1,H1, x1+a3, x2, x3-1; Y2,H2-11; Y3, H3-19.

Tested terminal	Earthed terminals	
	Direct	Trough resistors [Ω]
x1+a3	-	H1, H2,H3,Y0,Y1,Y2,Y3 (0.1); x2, x3 (0.02)
Y3	H1, H2, Y1, Y2	Y0(0.02); H3(400); a3,x1,x2,x3 (1)
Y0	-	H1, H2, H3, Y1, Y2, Y3 (0.02); x1, x2, x3,a3 (1)
H1	H2, H3, Y2, Y3	Y0(0.02); Y1(400); a3,x1,x2, x3 (0.1)

Table 4

In Fig. 3 it is represented the LV winding line terminals testing circuit diagram for LI, while Fig.4 encompasses the MV + HV winding neutral terminal testing circuit diagram for LI

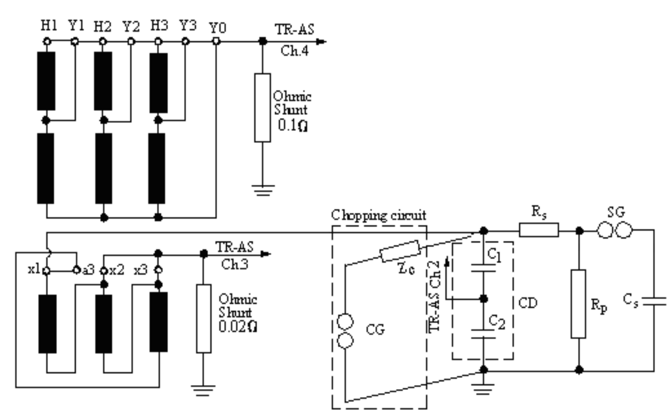


Fig.3 The LV winding line terminals testing circuit diagram for LI

As a Legend for the above figures one could note that: Cs is equivalent capacitance of impulse generator; C1is HV

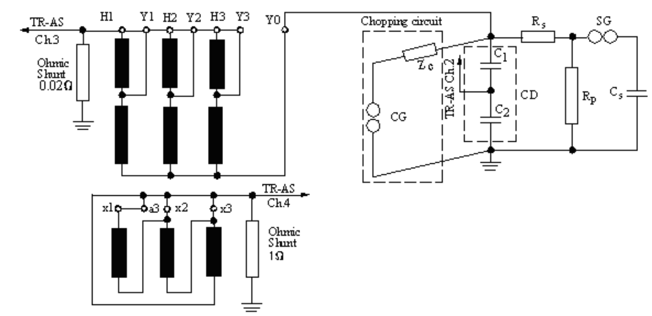


Fig.4 The MV + HV winding neutral terminal testing circuit diagram for LI

capacitance of divider; C2 is LV capacitance of divider; Rs is equivalent serial resistance of impulse generator; Rp is equivalent parallel resistance of impulse generator; CD represents capacitive divider; SG is the sphere–gap; CG represents the chopping–gap; Zc is the chopping circuit impedance (760 Ω).

Further, in Fig. 3 is depicted the MV winding line terminals testing circuit diagram for LI, while in Fig.4 the HV winding line terminals testing circuit diagram for LI.

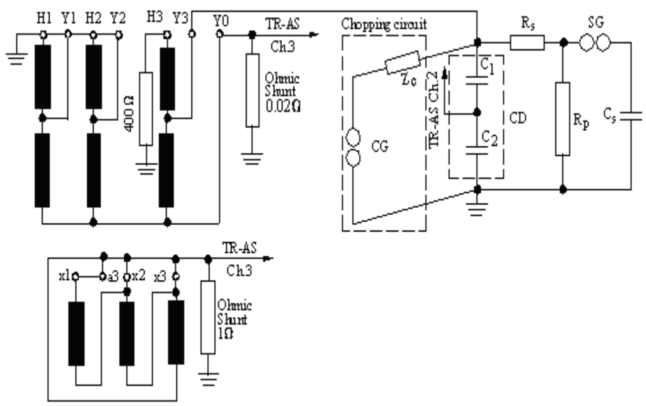


Fig.5 MV winding line terminals testing circuit diagram for LI

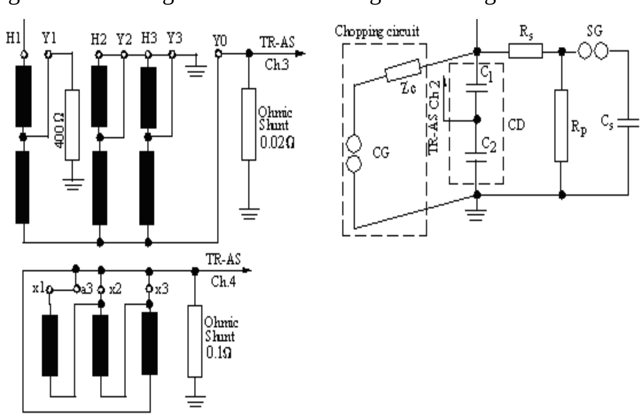


Fig.6 HV winding line terminals testing circuit diagram for LI

As a Legend for the above figures one could note that: Cs is equivalent capacitance of impulse generator; C1 is HV capacitance of divider; C2 is LV capacitance of divider; Rs represents the equivalent serial resistance of impulse generator; Rp is the equivalent parallel resistance of impulse generator; CD is capacitive divider; SG is the sphere–gap; CG is the chopping–gap; Zc is the chopping circuit impedance (760Ω).

In Figs. 7-9 there are presented the corresponding oscillograms. One could note that:

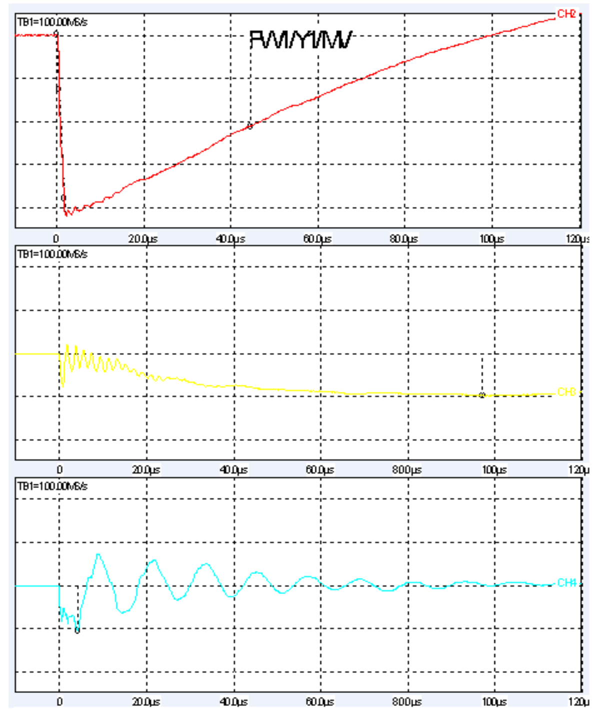


Fig.7 Regarding the CH_2 for U_p=774kV,T_1=1,92μs, T_2=44,7μs, CH_3 for I_p=1254A and CH_4 for I_p=270,1A

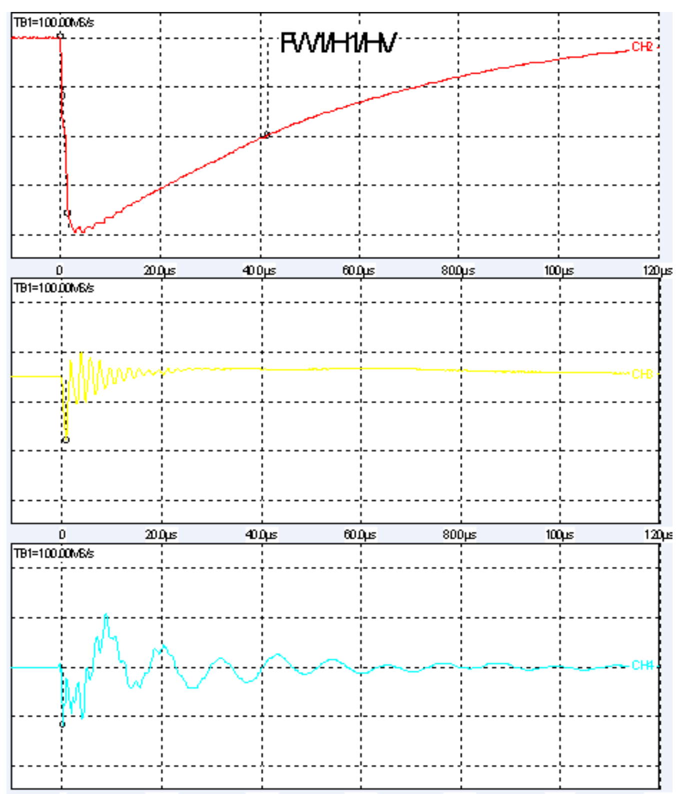


Fig.8 Regarding the CH_2 for U_p=1421,1kV,T_1=1,54μs, T_2=41,7μs, CH_3 - I_p=2639A and CH_4 - I_p=2385A

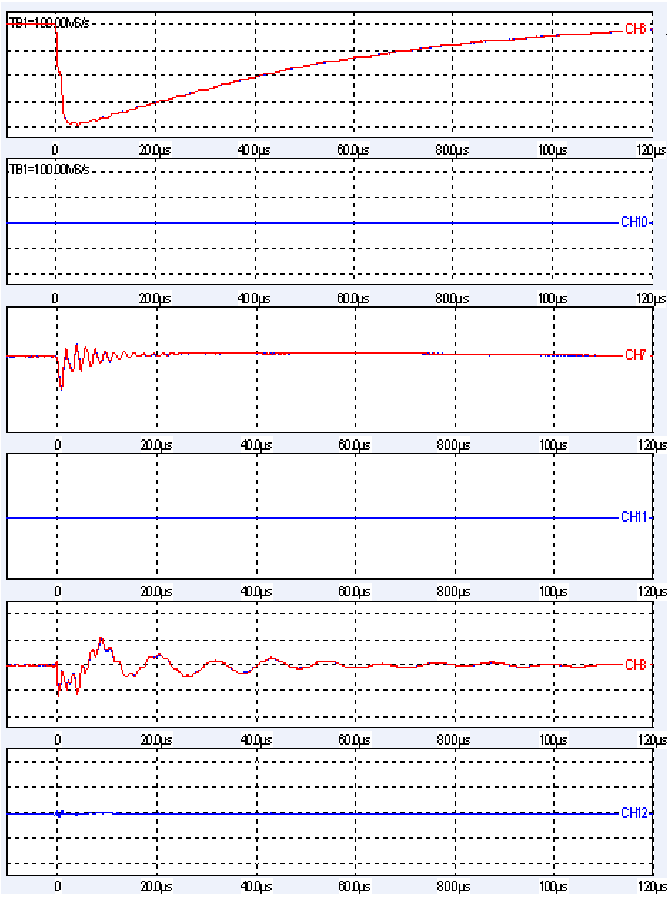


Fig.9 Comparison RW versus WF_1: CH_2 for U_p=1421kV,T_1=1,54µs, T_2=41,7µs, CH_3 - I_p=2639A, CH_4 - I_p=2385 A, CH_6 U_p=7224kV, T_1=1,54µs, T_2=41,6µs, CH_7 - I_p=1342A, CH_8 - I_p=117,1A, CH_{10} – COMP (CH_6-CH_2), CH_{11} – COMP (CH_7-CH_3), CH_{12} – COMP (CH_8-CH_4)

1. The up-peak value a testing voltage; T1 – front time; T2 – tail time; Tc – chopping time – parameters of testing impulse wave; Ip – current peak value measured on the tested phase.

2. RW is the reduced wave 50-75 %: FW-full wave 100 %..

3. Wave forms of voltage impulse during the tests were inside of the limits prescribed by the test norms.

As a test conclusion one could emphasize that he product passed the test.

V. Conclusion

This study was thought and conducted according to the recommendations and requirements given in the IEC standards, the ISO 14040 series of LCA standards.

The main purpose of the paper is to point out that way a holistic approach of technical, health care, environmental and economic aspects must be highlighted. The case study focused on the stage of reuse of a power autotransformer, presenting the full and chopped lightning impulses of tests in order to reintroduce the autotransformer in the electric networks and to continue its life cycle. No missing test standards or measurement procedures on energy use and other environmental parameters have been identified for power and distribution transformers and autotransformers.

References

[1] J. Ray, "The environmental impacts of electrical transformers", *The Electricity Forum. Electrical Transformers Explained,* Available at: http://www.ehow.co.uk/info_8388486_environmental-impacts-electrical-transformers.html , Accessed on 10 July 2014.

[2] NIEHS Working Group Report of National Institute of Environmental Health Sciences of US National Institutes of Health, "*Assessment of Health Effects from Exposure to Power-Line Frequency Electric and magnetic Fields"*, Brooklyn Park, Minnesota 16-24 June, 1998, available at: http://www.niehs.nih.gov/health/assets/docs_a_e/emf1.pdf , Accessed on 29 July 2014.

[3] VITO&BIOIS, Report on Distribution and Power Transformers, Contract N°. S12.515810 call ENTR/2008/039, "Sustainable Industrial Policy – Building on the Ecodesign Directive – Energy-Using ,Product Group Analysis/1", September 2010, Available at: http://www.ebpg.bam.de/de/ebpg_medien/entr2/402_studyd_10-10_part1-7.pdf , Accessed on 10 July 2014.

[4] LCA study of current transformers", DANTES project co-funded by the EU Life-Environment Program, Available at: http://www.dantes.info/Publications/Publication-doc/DANTES%20ABB%20LCA%20study%20of%20instrument%20transformers.pdf , Accessed on 19 July 2014.

[5] C.A.Bulucea, D.A. Nicola, N.E. Mastorakis, P. Dondon, C.A. Bulucea, D.C. Cismaru, "Fostering the Sustainability of Power Transformers", Recent Researches in Environmental & Geological Sciences, Proceedings of 7th WSEAS International Conference on Energy and Environment (EE'12), Kos Island, Greece, July 14-17, 2012, pp.72-81.

[6] Electromagnetic Compatibility – the EMC Directive 89/336/EEC, 1992, Available at: http://ec.europa.eu/enterprise/policies/european-standards/harmonised-standards/electromagnetic-compatibility/index_en.htm, Accessed on 1st September 2014

[7] Guide to the implementation of directives based on the New Approach and the Global Approach, European Commission, 2000, Available at: http://ec.europa.eu/enterprise/policies/single-market-goods/files/blue-guide/guidepublic_en.pdf , Accessed on 14 June 2014.

[8] Directive 2004/40/EC of the European Parliament and of the Council – electromagnetic fields and waves, of 29 April 2004 on the minimum health and safety requirements regarding the exposure of the workers to risks arising from electromagnetic fields and waves.

[9] WHO - World Health Organization, "Extremely Low Frequency. Environmental Health Criteria", Vol.238, Geneva, World Health Organization, 2007

[10] ICNIRP – International Commission on Non-Ionizing radiation Protection, "Exposure to static and low frequency electromagnetic fields, biological effects and health consequences (0-100 kHz)", Bernhardt JH et al, eds, Oberschleissheim, International Commission on Non-Ionizing radiation Protection, 2003 (ICNIRP 13/2003)

[11] WHO - World Health Organization, "Electromagnetic fileds (EMF)". Programme of WHO, available at: http://www.who.int/peh-emf/about/WhatisEMF/en/, Accessed on 15 August 2014.

[12] IEC 60076-1 (2000) series on Power Transformers, Available at:: http://webstore.iec.ch/ , http://www.saiglobal.com/pdftemp/previews/osh/as/as60000/60000/60076.1-2005.pdf , Accessed on 25 August 2014.

Enterprise Risk Management and its Value Creation Transmission Mechanism

Fong-Woon Lai

***Abstract*—**This paper discusses the theoretical argument towards establishing the value creation mechanism for enterprise risk management implementation. It highlights the notion of managing firms' systematic and unsystematic (specific) risk via an ERM implementation framework that leads to the enhancement of shareholders' value. The mechanism through which the firms' value enhancement takes place is theorized by a strategic conceptualization of risk premium model. The model cites managing the firm's four classes of risks, namely macroeconomic, tactical, strategic, and normative risks. Hence, this paper investigates the validity of the theorized value creation transmission mechanism of the proposed ERM framework via the strategic conceptualization of risk premium model.

***Keywords*—**CAPM, enterprise risk management, transmission mechanism, strategic risk premium.

I. Introduction

THIS paper posits that implementation of enterprise risk management (ERM) program by firms can create value for shareholders with the notion of managing firms' systematic and unsystematic (specific) risk via an ERM implementation framework that leads to the enhancement of shareholders' value. The mechanism through which the firms' value enhancement takes place is theorized by a strategic conceptualization of risk premium model. The model cites managing the firm's macroeconomic (systematic) risk as well as three classes of unsystematic risk, namely tactical risk, strategic risk, and normative risk. Hence, this paper investigates the validity of the theorized value creation transmission mechanism of a ERM implementation framework underpinned by the strategic risk premium model.

The ERM conceptual framework is such that its implementation will lead to some tangible and intangible benefits to the firm in ways of optimizing the risk/return profile of the company, reducing earning volatility, strengthening management's confidence in business operations and risk monitoring, creating smooth governance procedures, enriching corporate reputation, improving clarity of organization-wide decision making and chain of command, encouraging corporate entrepreneurship, and boosting enterprise's profitability [1][2][3]. These benefits derived from ERM implementation, in turn, will define the distinctive competitiveness of the firm.

The above benefits will lead to lower cost of capital and contribute to improved business performance, i.e. improved price-to-earnings ratio of share price. The lowering of cost of capital is due to risk premium reduction as a result of the firm lowering its systematic and idiosyncratic or unsystematic risk profile. The improved price-to-earning ratio of the firm's share prices on the other hand, happens because investors are willing to pay a higher price for the company's share at a given level of earning-per-share (EPS) due to the firm's perceived lower risk profile. These two causal relationships represent the value creation from ERM program.

II. The Proposed ERM Implementation Framework

We propose an ERM implementation framework to encompass 3 dimensions (i.e. structure, governance and process), which further extends out to 7 areas. These 7 areas are in turn operationalized by 14 implementation elements. For instance, the *structure* dimension is articulated to be covering two areas, i.e. ERM definition, and performance measurement, and these two areas are operationalized by four implementation elements. Similarly, the *governance* dimension is to cover two areas (i.e. information and roles, and compliance) with four implementation elements. On the other hand, the *process* dimension is to include three areas (i.e. integration of business strategy and objectives, risk identification and response, and risk quantification) and with six implementation elements. Table I presents the relevant implementation elements (i1 to i14) operationalizing the proposed ERM framework which correspond to the relevant areas in the respective dimensions.

III. Theoretical Underpinning

We theorize that ERM implementation intensity will determine the amount of benefits received by the firm. The benefits received from such effective execution will have a long-term positive impact in creating value for the corporations' shareholders. This value creation process is achieved via a two-pronged process.

Firstly, shareholders' value is created by way of lowering the corporations' cost of capital which takes place through a dynamic framework of risk premium reduction mechanism.

Secondly, the value is created by means of a generic improvement of business performance. This improvement encompasses all functional areas such as finance, operations, marketing, human resources, and governance. The final result of this two-pronged value creation process is the higher return

F. W. Lai is with the Universiti Teknologi PETRONAS, Perak, Malaysia (phone: +605-3687743; fax: +605-3656280; e-mail: laifongwoon@petronas.com.my).

Table I: Dimensions and Areas of ERM Implementation

Dimension	Area		Element / Statement
Structure	ERM Definition	i1	Provides common understanding of the objectives of each ERM initiative
		i2	Provides common terminology and set of standards of risk management
	Performance measurement	i3	Identifies key risk indicators (KRIs)
		i4	Integrates risk with key performance indicators (KPIs)
Governance	Information and roles	i5	provides enterprise-wide information about risk
		i6	Enables everyone to understand his/her accountability
	Compliance	i7	Reduces risk of non-compliance
		i8	Enables tracking costs of compliance
Process	Integration of business strategy and objectives	i9	Integrates risk with corporate strategic planning
		i10	Integrated across all functions and business units
		i11	ERM strategy is aligned with corporate strategy
		i12	Aligns ERM initiatives to business objectives
	Risk identification and response	i13	Provides the rigor to identify and select risk responses (i.e. risk- avoidance, reduction, sharing and acceptance)
	Risk quantification	i14	Quantifies risk to the greatest extent possible

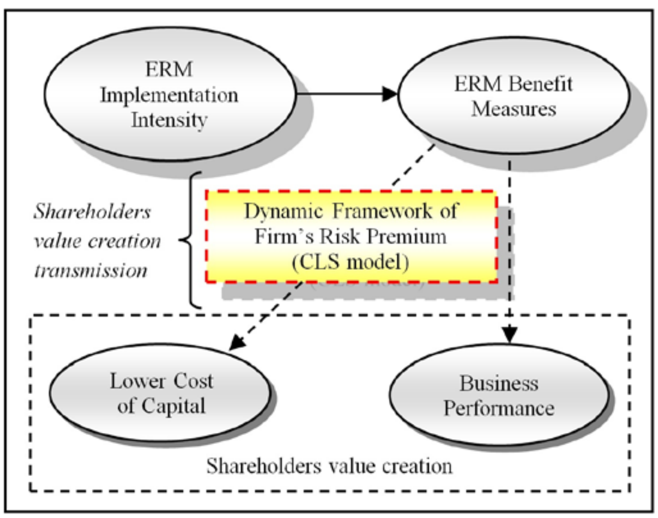


Fig 1. Constructs in the theorized causal relationship model

of share prices for shareholders. These theoretical relationships are depicted in Figure 1.

A. Capital Asset Pricing Model

Ref [4][5][6] introduce Capital Asset Pricing Model (CAPM) by using the concepts of diversification and asset allocation, coupled with the modern portfolio theory as building blocks [7][3]. Variables that are involved in CAPM's formulation are systematic risk, specific risk (unsystematic risk), beta, and risk premium. Core to CAPM's notion is the division of the security's total risk into two parts, namely the systematic risk (also called market risk) and the unsystematic risk (also called firm-specific or unique risk). CAPM explains systematic risk as the component of an asset's price variance that is affected by the movement of the general market. It is also referred to as market risk. The covariance of the market and the asset's price movements is measured by a coefficient called Beta (β). Thus, systematic risk is the risk of holding the market portfolio [7].

Specific risk of an asset, on the other hand, is the other component of the asset's price variance that is unique to itself and has no correlation to the general market movement. This element of specific risk can be eliminated through diversification within an asset class. Systematic risk, however, cannot be diversified away. Nevertheless, it can be hedged. According to CAPM, the marketplace is efficient and compensates investors only for taking systematic risk. Exposure to specific risk (idiosyncratic risk) will not be compensated because CAPM expects investors to diversify that risk away without reducing returns and at no cost in their portfolios' asset class [7]. The expected return of an asset (portfolio) under CAPM is given by:

$$E(R_i) = R_f + \beta^m_i\,[\,E(R_m) - R_f\,]$$

where $E(R_i)$ is the expected return on asset$_i$; R_f is the return on a risk-free asset; β^m_i measures the covariance of asset$_i$'s return to that of the market; $E(R_m)$ is the expected return on the market. Since β (beta) measures the sensitivity of an investment's return to movements of the entire market, stocks with a beta of less than 1 will be less risky than the market whilst those with a beta greater than 1 will be more risky than the market [3]. In the CAPM formula term, the product of $\beta^m_i\,[\,E(R_m) - R_f\,]$ represents risk premium for stock i. In other words, it is the compensation for the stock's exposure to the systematic risk.

In the context of NCFT's uniform assumptions of such a simple world (i.e. perfect and complete markets), [8] saw a super-efficient portfolio as represented by the market portfolio [7]. Ref [3] pointed out that although CAPM's formulation is explained in terms of stock returns, it has a parallel implication in capital budgeting situations where:

$r = r_f$ + (project beta) $(r_m - r_f)$, and
r = required rate of return on the project.

Hence, the required rate of return on a project increases in tandem with the project's beta. It then follows that the true cost of capital is influenced by the risk profile of the project for which the capital is put to use [3].

B. Unsystematic Risk and Risk Premium: CAPM modification

CAPM's theoretical framework clearly indicates that there is no favorable risk pricing effect for the reduction in unsystematic risk, hence implying that any deliberate effort on the part of the firms to manage their unsystematic risk will not be compensated. However, assuming if there would be a positive effect on managing unsystematic risk, how would this notion impact the variables in the CAPM formula then? It should follow that variable r, representing the required rate of return for an asset or a project, should be reduced due to the lower risk profile (either perceived or otherwise). A lowered r, which is also used for discounting firms' expected cash flows, should yield a higher firm value as follows:

$$\text{Firm value} = \sum E(CF_t) / (1 + r_t)^{\,t}$$

where $\sum E(CF_t)$ is the sum of all expected cash flows, t is the time period, and r is the discount rate. And according to NCFT, on the basis of maximizing shareholders' wealth, the appropriate firm-decision rule is for managers to pursue all investment opportunities that will yield a positive net present value (NPV) [7].

In the CAPM's formula $E(r) = R_f + \beta^m_i\ [\ E(R_m) - R_f\ ]$, where R_f is the risk free rate, β^m_i is the firm's (asset) beta or the correlation coefficient of that particular firm to the market portfolio. The term $[\ E(R_m) - R_f\ ]$ is the market potfolio's risk premium and the term $\beta^m_i\ [\ E(R_m) - R_f\ ]$ is the firm's risk premium. The reduction of expected or required rate of return, E(r), will be significantly influenced by the firm's risk premium term, or $\beta^m_i\ [\ E(R_m) - R_f\ ]$. The return on a risk-free asset (R_f) and the expected return on the market $[\ E(R_m)\ ]$ are externality variables to the firm. Hence, there is nothing much managers can do to influence them managerially other than to hope for market forces to change these variables in the favorable direction for risk pricing reduction. The same applies to the firm's beta (β^m_i). Beta measures the covariance of the firm's return to that of the market portfolio, or in other words, it is the measurement for the firm's systematic risk. In this light, the only way the beta of the firm would change is by way of the firm varying its existing business line so that its business risk profile would shift in relation to that of the market. One example of this is to undertake business diversification through either the firm's product lines or target markets. But this managerial maneuvering affects the systematic risk aspect of the firm. As such, in order to capture the positive effect of managing a firm's unsystematic risk and reflect it in the CAPM formulation, we may attempt to include an additional variable, i.e. µ, to impact the firm's risk premium term. This variable should take a negative value so that it can have diminishing effect on the term $\beta^m_i\ [\ E(R_m) - R_f\ ]$ such that the new risk premium term of the firm becomes $\beta^m_i\ [\ E(R_m) - R_f\ ] - \mu$. Thus, the modified CAPM formula that recognizes the effect of managing a firm's unsystematic risk shall be:

$$E(R_i) = R_f + \beta^m_i\ [\ E(R_m) - R_f\ ] - \mu$$

Conceptually, it should be noted in the above formula that the effect of unsystematic risk does not come in the form of a direct reward for bearing them in the way similar to bearing systematic risk in the asset pricing model. Rather, it is the reward that comes from the nature for its successful reduction or elimination. This notion runs contrary to the concept of market risk in asset pricing whereas investors are being rewarded for bearing market risk because it is not diversifiable. Nonetheless, the notion of unsystematic risk management does not suggest that firms be rewarded for bearing unsystematic risks. This is because those risks are diversifiable.

Instead, we suggests that the firms to be treated favorably by the market for their ability to reduce and capability to manage those unique risks facing the firms. The rationale for this reward system is by giving a due recognition to managing the firms' unsystematic risk which can result in firms enhancing their capability to improve earnings. This earnings improvement can come in the form of reducing or eliminating negative profit variation, reducing cost of financial distress, minimizing agency problem, enhancing corporate brand name and the likes. Managers, thus, should endeavor to manage firms' unsystematic risk well enough to earn the largest possible value of -µ as possible from the investors in order to reduce the firms' required rate of return (risk premium) or cost of capital.

In the context of asset pricing, unsystematic risk comes from the hypothesis where it is postulated that investors would welcome such a reduction in firms' specific risks. As a result, investors would demand a relatively lower risk premium for their investment in the firm.

C. The CAPM rebuttal

According to modern financial theory, managing unsystematic risk will not be rewarded by the stock market [3]. However, [3] highlighted that the idea of managers should not be concerned with managing unsystematic risk is contradicting with the notion of corporate strategy and the theory of strategic management. This contradiction is vividly highlighted with the account by [9] on managerial behavior that: "Given a business opportunity producing a cash flow, the risk/return model emphasizes that market value will be affected by managing systematic risk rather than unsystematic, or company specific risks. Ironically, managers spend most of their efforts on these very real company specific risks (such as competitive retaliation, labor relations, or even bankruptcy) which are both obvious and immediate, as well as being potentially disastrous to personal and organizational welfare". This managerial situation is very true considering that unsystematic risks are associated with firms' specific resources and competencies. Moreover, the risks are also linked to the firms' operating environment [3]. To this end, [10] argued that managing these unsystematic risks become inherent in the concept of matching corporate resources and competencies to opportunities within the firms' environment.

According to [3], there had been many studies that had showed the success of companies through strategic management that relied on the strategic adaptation by skillful, rigorous, and continuous management of unsystematic risk. Examples are those empirical studies of company success by [11][12], theoretical explanations in industrial economics [13], a massive study of industrial history [14]. Apart from these, in the area of organizational theory, studies by [15][16][17] indicated effective management of unsystematic risk was the central cause of organizational evolution, where "the cause that determines which organizations survive and grow and which decline and die" [3].

In the marketing domain, one example of unsystematic risks in the context of corporate strategy management is the issue of entry barriers. For instance, [18] cited specific management of unsystematic risk in managing the risk of a new entrant into a market where a firm is competing. To manage this risk it will entail the formulation of strategy for deterring such new entrants. Hence, corporate strategy will require managers to devote attention to barriers of entry. The competitive strategy theory by [19] underscores the importance of managing barriers of entry under various conditions for firms to stay competitive in the market place. Studies in industrial organization economics such as [20][21] also give generic conclusion that the profit potential of an industry or individual firm is influenced by the height of barriers to entry.

Thus, a manager who does not manage unsystematic risk (i.e. entry barriers as in the above examples) is to ignore an important element of strategy [3].

IV. ERM Value Creation Transmission Mechanism

We can conclude from the above discussion that modern financial theory (neo-classical finance theory) and strategy theory offer different notions on the efficacy of corporate risk management, specifically in the context of ERM. In effect, the conclusions of modern financial theory also run contrary to that of classical theory (i.e. Markowitz) in this respect. Nevertheless, as [3] aptly put it: "To alter either result is to disrupt significantly the logical structure of the underlying discipline". How then, can one provide plausible and sensible explanations in an effort to describe this discrepancy and to even reconcile the difference? In this light, it will be of significance to provide a theoretical linkage among the three schools of thought, namely the classical finance theory, neo-classical finance theory, and strategy theory. This paper, hence, endeavors to provide such linkage.

For starter, we highlight the opposite views of neo-classical financial theory (NCFT) and classical/strategy theory by drawing reference to some anecdotal evidences of the practices of corporate risk management in the real world. Risk management in the context of NCFT would only mean diversification, asset allocation and to a certain extent, the hedging or transfer of risk [7]. However, [7] also pointed out that, in the real world realm, corporate risk management activities include "a logical and systematic method of establishing the context, identifying, analyzing, evaluating, mitigating, monitoring and communicating risk associated with any financial activity, function or process in a way that will enable organizations to minimize financial losses and maximize financial opportunities".

Even so, the description by [7] on the ultimate purpose of corporate risk management (i.e. minimizing financial losses and maximizing financial opportunities), in our view, is still not as exhaustive as what we view the implementation of ERM can achieve. We conceptualize that ERM implementation framework should also encompass the goals of dealing with all business activities risks, ranging from financial to operational, such that to minimize/maximize not only financial losses/opportunities, but also other aspect of business losses/opportunities such as reputation, branding, governance, and corporate entrepreneurship, to name a few.

Another distinction of our proposed ERM implementation framework as compared to the notion of risk management by NCFT lies in the management of unsystematic risk or firm-specific risk. Apart from systematic risks, ERM also highlights the importance for managing unsystematic risk with the belief that it will lead to an enhanced shareholders' value. This concept blends well with the value-enhancing notion as postulated by strategy theory.

To bridge the contradicting arguments between modern financial theory and strategy research with regard to managing the firms' unsystematic risk, it requires a model that fits well within the two contradicting schools of thought. This model shall serve to describe the value creation transmission mechanism of ERM. One such plausible model is with respect the idea for to the determination the firm's risk premium. Thus, this paper conceptualizes a strategic risk premium model to theorize value creation in managing the firm's unsystematic risk.

Risk premium is a crucial element for the firms. It has a profound impact on firms' cost of capital. Firms with risky profiles in the eyes of investors will suffer from incurring higher costs when raising capital. This comes in the form of either selling equity at lower prices or issuing bond/debt with higher coupon/interest rates [22]. Firms encountering this situation will face an unfavorable strategic opportunity set [23]. Besides, higher capital costs will return lower present value when discounting firm's future earnings. As such it can become a source of competitive disadvantage when a firm faces its rivals in accessing capital markets [7][24].

This study adapts a model called "a dynamic framework of a firm's risk premium" developed by [24]. Ref [24] assumes that investors do care about firm-specific risk. This is owing to the fact most investors are not as fully diversified and markets are not as perfect as CAPM assumes. The interactions among constructs in the model take reference from (i) information economics, (ii) resource-based view of the firm, and (iii) the industry structural view of strategy [24].

ISBN: 978-1-61804-255-2

The information economics highlights the existence of information asymmetries in the market and notices that the belief among market participants to be heterogeneous. The resource-based view of the firm provides explanation that the asymmetries that happen in the resources markets are caused by the characteristics of the resources in which they are lumpy, heterogeneous, and to be acquired with a cost. The industry structural view of strategy on the other hand, sees asymmetries in market power distribution in the input and output markets [24].

According to [24], investors are exposed to various classes of firm-specific risk in a world of partial diversification and imperfect markets. This notion forms the core of our strategic risk premium model for ERM implementation. The postulated strategic risk premium model extends CAPM's notion where apart from recognizing the sensitivity of macroeconomic uncertainties, a firm's risk premium will also be influenced by its sensitivity to three additional classes of firm-specific risks, namely the *tactical*, *strategic*, and *normative* risks. Ref [24] highlights that tactical risk exists mainly in information asymmetries, whilst strategic risk comes from imperfections in the resource and output markets, and finally normative risk presents itself in the forces that define institutional norms.

Ref [24] highlights the notion that there are dynamic relationships between unsystematic risk (i.e. tactical, strategic, and normative risks) and a firm's risk premium as depicted in Fig. 2. Thus, firm-specific activities and skills derived from the active management of those risks will influence a firm's risk premium. This argument is well supported by the current theories of strategy [25]. However, this assertion is apparently inconsistent with CAPM which does not acknowledge such a relationship. CAPM defines that all firm-specific activities, which are measured by the variance of the error term in the market model, as unsystematic risk. This unsystematic risk is not correlated with risk premium. Thus, it is irrelevant [7][24].

Thus, the conceptualization of the strategic risk premium model takes a multivariate approach to include such factors as macroeconomic, tactical, strategic, and normative risks; of which the latter three risks are omitted by the single-factor market-based CAPM. The strategic risk premium model also pays due recognition to the dynamic of the continuous interplay between elements of the firm's activities and market forces [24]. This approach of conceptual assertion not only comes in tandem with the studies of strategic management, but also offers to connect the former with the theories in financial economics in providing a solid and robust conceptual framework for *enterprise risk management* (ERM). This linkage of theories from the two disciplines (i.e. strategic management and financial economics) enables the building of a new theory postulating that ERM can lead to improved business performance and enhanced shareholders value.

Table II presents a summary of the structural framework and the relevant literature relating to the conceptualization of the strategic risk premium model.

V. THE HYPOTHESES

The postulated strategic risk premium model for ERM implementation highlights managing the firms' four classes of risks, namely, macroeconomic, tactical, strategic and normative risks (refer to Fig. 2). By managing these four classes of risks, the risk premium expected by the debt-holders will be lowered, thus reducing the cost of capital for the firms. This in turn, is a form of value creation to the shareholders since the shareholders can now share less of the company's earnings with the debt-holders in interest (for loan financing) or coupon (for bond financing) payments.

The theoretical argument presented above suggests that a firm's specific activities in managing its three classes of unsystematic risk can have a positive effect on reducing the firm's risk premium. This notion forms the core of our managing firms' theorized ERM value creation transmission mechanism.

Hence, this paper develops the below hypotheses to theorize the value creation of enterprise risk management and its transmission mechanism:

H_1: *ERM implementation will reduce firm's macroeconomic risk*

H_2: *ERM implementation will reduce firm's tactical risk*

H_3: *ERM implementation will reduce firm's strategic risk*

H_4: *ERM implementation will reduce firm's normative risk*

To attest the validity of the presented argument on the strategic risk premium model and its value creation transmission mechanism, reference can be made to the rating criteria of the Malaysian rating agencies. For instance, one of the rating agencies, RAM, affirms the reduction of the firms' *tactical risk* in relation to its favorable rating profile for managing the (i) **financial risk**, i.e. profitability and coverage, funding structure, capital leverage, cashflow stability and adequacy, financial flexibility and liquidity; and (ii) **corporate governance issues**. Similarly, managing *strategic risk* embraces RAM's favorable rating for managing (i) **industry risk,** i.e. growth potential, vulnerability to industry factors, barriers to entry; (ii) **business risk**, i.e. *market risk* – basis of competition, market position and size, product/service diversity, customer analysis; *operational risk* – availability of

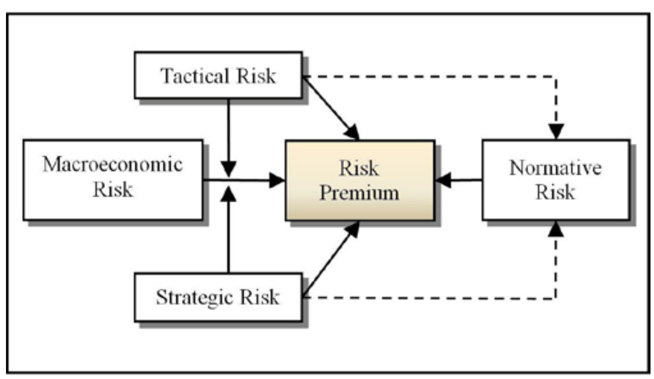


Fig. 2. The Strategic Risk Premium Model

Table II: Strategic Conceptualization of Risk Premium

Firm-specific Risk Class	Definition	Source of Risk	Relevant Literature	Risk Management Objective	Action
Tactical	Uncertainty in firm's expected earnings	Informational Asymmetries	Earnings / Governance / Liquidity / Information management Hedging & Real options	To lower the variance of expected earnings through minimizing earnings surprises/ variation from informational asymmetries	Engage in financial tactics, e.g. hedges and real options contracts
Strategic	Uncertainty in performance outcomes of committed resources	Resource and output markets imperfection	Strategy / Firm- structured / Resource-based / Knowledge-based view Strategic options	To isolate earnings from macroeconomic and industry-specific disturbances	Shape market forces in firm's competitive arena to gain advantage
Normative	Incurring risk premium for failing to comply with institutionally expected norms	Forces of institutional norms	Diminishing competitive advantage view Dynamic market forces view	To reduce cost and avoid bearing additional risk without the promise of higher return	Comply to industry rules and conform to institutionally expected norms

raw materials, efficiency of assets, cost structure, labor relations, credit controls, inventory management; and (iii) **diversification factor** [26].

Further research can be carried out by empirically testing the above-mentioned hypotheses to validate the theorized causal relationships among the constructs of ERM implementation framework with the highlighted four classes of a firm's systematic and unsystematic risks. The causal relationship would signify the value creation transmission mechanism as espoused in this paper.

VI. CONCLUSION

The above discussion demonstrates that the effect of ERM implementation is significant in reducing firms' systematic and firm-specific risks. This study links the strategic risk premium model as value creation transmission mechanism to the ERM implementation. Thus, reducing the firms' macroeconomic, tactical, strategic and normative risks implies the lowering of the firms' cost of capital through reducing the firms' risk premium.

In a nutshell, the theoretical argument presented in this paper in the light of the posited strategic risk premium model implies that corporations are poised to benefit from a favorable credit profiling rating from rating agencies with an effective ERM implementation program. This will lead to reduced risk premium and lowered cost of capital when the firms attempt to raise fund with the issuance of various debt instruments in the capital markets. As for the shareholders, a lowered risk premium demanded for the firm's debt instruments essentially means that a bigger portion of the company's earnings will be made available for distribution to the equity-holders as dividend payments, thus enhancing shareholders' value in the company.

REFERENCES

[1] M. Crouhy, D. Galai, and R. Mark, “The Essential of Risk Management”, McGrawHill, New York, 2006.

[2] M.A., Bailey, L. Bloom, and E.T. Hida, “Assessing the Value of Enterprise Risk Management,” Deloitte Development LLC. 2004.

[3] R.A. Bettis, “Modern Financial Theory, Corporate Strategy and Public Policy: Three Conundrums”, Academy of Management, The Academy of Management Review (pre-1986), vol.8, no.3, pp.406-415, 1983.

[4] J.L. Treynor, “Market Value, Time, and Risk”, 1961. Unpublished manuscript dated 8/8/61, No. 95-209.

[5] W. Sharpe, “Capital Asset Prices: A Theory of Market Equilibrium under Conditions of Risk”, Journal of Finance, vol.19, pp.425-442. 1964.

[6] J. Lintner, “The Valuation of Risk Assets and the Selection of Risky Investments in Stock Portfolios and Capital Budgets”, Review of Economics and Statistics. 47:1, pp. 13–37, 1965.

[7] D.P. Belmont, “Value Added Risk Management in Financial Institutions”, John Wiley & Sons, Singapore. 2004.

[8] Tobin, “Liquidity preference as behavior towards risk”, The Review of Economic Studies, 25, 65-86, 1958.

[9] M.S. Salter, and W.A. Weinhold, “Diversification through acquisition”, The Free Press, New York. 1979.

[10] K.R. Andrews, “The concept of corporate strategy”, 2nd ed. Richard D. Irwin, Homewood, Ill. 1980.

[11] S. Hall, “Encoding/decoding.” Culture, Media, Language. Ed. Stuart Hall et al. New York: Routledge, 1980. 128-138.

[12] H. Mintzberg, “The Strategy Concept I: Five Ps for Strategy”, California Management Review, Fall 1987.

[13] E.T. Penrose, “The Theory of the Growth of the Firm”. Oxford University Press: New York. 1959.

[14] D. Chandler, “The Visible Hand: The Managerial Revolution in American Business”. Cambridge, MA: Belknap Press of Harvard University Press. 1977.

[15] S, Chakravarthy, “Adaptation: A Promising Metaphor for Strategic Management”, Academy of Management Review, 7:35-44, 1982.

[16] J. Child, “Organizational structure, environment and performance: the role of strategic choice”. Sociology, 6(1), 1-22. 1972.

[17] C.E. Summer, “Strategic behavior in business and government”. Boston, MA: Little, Brown. 1980.

[18] J.C. Van Horne, “Financial Management and Policy”, 5th ed., Prentice-Hall, Englewood Cliffs, New Jersey. 1980.

[19] M.E. Porter, “Competitive strategy”, The Free Press, New York. 1980.

[20] W.G. Shepherd, “The Economics of Industrial Organization”. Englewood Cliffs, N.J., 1979.

[21] F.M. Scherer, “Industrial market structure and economic performance”, 2nd ed., Rand McNally, Chicago. 1980.

[22] Tarek, “Default, Liquidity and Credit Spread: Empirical Evidence from Structural Model”, IUP Journal of Financial Risk Management, vol.6, no.2, pp.46-61, Hyderabab. 2009.

[23] T.E. Copeland, F.J. Weston, J. Fred and K. Shastri, “Financial theory and corporate policy”, 4th ed., Pearson Addison-Wesley, Boston. 2005.

[24] S. Chatterjee, M.H. Lubatkin, and W.S. Schulze, “Toward a strategic theory of risk premium: moving beyond CAPM,” The Academy of Management Review, vol.24, no.3, pp.556-567, 1999.

[25] N. Graf, “Uncovering the risk conundrum: a strategic perspective,” EHL-FORUM, no.4, June, 2004.

[26] RAM, “Rating Methodology: Corporate Credit Ratings”, April, Rating Agency Malaysia Berhad [Online], Available from http://www.ram.com.my [2008, July 21]. 2006.

Fong-Woon Lai is a senior lecturer at Universiti Teknologi PETRONAS in Malaysia. He holds a Bachelor of Science degree in Business Administration (Finance) and a Master of Business Administration (Finance) from the University of Nebraska-Lincoln, USA. He obtained his Ph.D (in enterprise risk management) from the University of Malaya, the oldest university in Malaysia.

He has been teaching in higher learning institutions since 1998. Prior to joining education line, Dr. Lai has worked in two stock broking companies in Malaysia. He held an Investment Advisor’s Representative License issued by the Malaysian Securities Commission in 1997. He was also an external writer for licensing examinations conducted by an industry authority in the country.

Dr. Lai has also published in indexed journals and presented in local and international conferences his research papers in the areas of corporate finance and risk management, business process re-engineering and higher education research. Dr. Lai’s past and present professional body memberships include the Australasian Institute of Banking and Finance, Malaysian Institute of Management, Professional Risk Managers International Association and Malaysian Association of Risk and Insurance Management.

Fixed productive assets management on the base of power equipment state assessment system: system implementation efficiency

Stepan A. Dmitriev, Alexandra I. Khalyasmaa and Sergei E. Kokin
Ural Federal University named after the first President of Russia B.N. Yeltsin

Abstract—**Analysis results of current and long-term strategies of engineering policy control in integrated power grid are presented in the present article. Perspective trends for implementation of new adaptive approach to fixed productive assets management on the base of data obtained from diagnostics and intelligent systems of actual technical state assessment of electric mains objects are defined. The authors attempted to estimate similar solutions efficiency at the initial stage of risk management system building – that is creation of automated system of actual state assessment.**

Keywords—Assets management, equipment state, management strategy, economic efficiency, risks management, power equipment, operation lifetime.

I. INTRODUCTION

In the modern context network facility management is inexorably associated with wide use of automated decision support systems. Implementation of modern monitoring and diagnostics systems, new measuring means and also systems transfer and storage of information concerning objects state and network-operating parameters allows creation of automation facilities complex for power equipment and power lines life cycle control. High level of fixed productive assets depreciation, reaching 56-61% in some electrical mains [1], sufficient electric power losses in electrical mains and high operating expenses, exceeding expenses for foreign analogs by 40%, and also long time for damaged components recovery - are the main prerequisites for creation of facilities mentioned above.

Prerequisites mentioned above define actuality of development and implementation of modern systems of power grid basic assets management. The present systems are designed for solving complex multicriterion control problems [2]: determination of power supply development vector; selection of place of influence on power energy transportation; perspectives assessment; forecasting of future state and development planning with consideration of consequences impact. Risk is any probability event which impacts on scheduled development process of power supply system and/or on functional state of both separate component of power energy transportation system and complex system as a whole.

II. PRODUCTION ACTIVITY OF POWER GRID PLANT

Production activity of any power grid plant is inexorably associated with its productive assets management for reliable, high quality power supply of consumers for efficient and safe operation of network infrastructure. Operational reliability of network facility is defined by technical state of system components [3], which depends on the level of *technical maintenance and repair* of separate power equipment, buildings, structures and constructions and also, considering large production systems emergence, it depends on approaches to the whole power grid facility *management strategy*. Selection and determination of management strategy are inseparable from processes of *system state forecasting and development planning*.

In the present time 3 approaches to technical maintenance and repair are applied on electrical power plants:

- ***Preventative and predictive maintenance,*** assuming repair cycle with predetermined sequence and scope of necessary procedures and also intervals between them. The present type of repairs and maintenance may assume variable-based approach to scope of performed works depending on equipment operation lifetime. The present approach is the main one in RF power industry.
- ***Emergency reconditioning repair*** or on-failures maintenance. Equipment, nodes and apparatus are repaired or replaced by the reason of their breakdown or in case of no possibility of their further operation. The present approach is appropriate when failures effects don’t cause substantial damage and preventive measures and diagnostics are more expensive than damages repair. In case of state monitoring systems presence [4-6] (specific gas concentration in power transformer tank, overheating of coils or contact connections etc.) the present approach allows taking preventive measures for failures prevention.
- ***On-condition maintenance*** is one of the most perspective types of maintenance, it doesn’t assume predetermined scope and time of repair operations performance; repair is performed in accordance with actual state of objects on the base of data obtained by automated monitoring systems, visual inspection among other things with the use of intelligent tools for diagnostics information processing. The present approach allows sufficient reduction in expenses for maintenance and

repair as compared to preventative and predictive maintenance and optimal distribution of power grid resources. Implementation of the present type of maintenance and repair assumes presence of complex systems of actual state monitoring.

Risk management is a perspective approach to productive assets management. Risk management is ***a set of methods for identification, analysis and elimination of risk factors integrated in system of monitoring, planning and corrective actions.*** Risk management procedures are presented in Fig. 1.

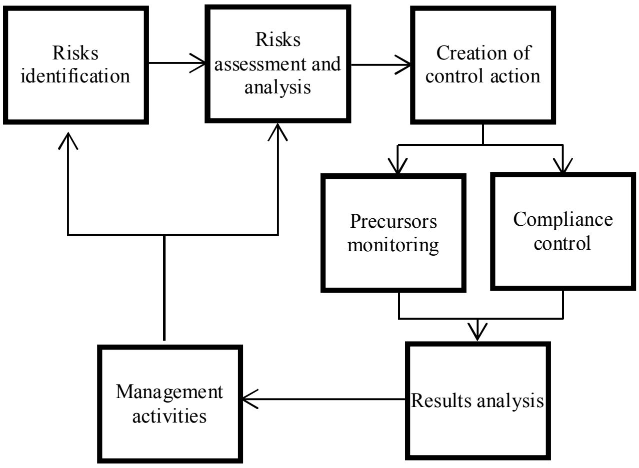


Fig. 1. Risks management procedures

Risk management is an adaptive approach, wherein strategy for productive assets management of power grid plant is selected in accordance with current situation – object technical state, reliability, probabilistic characteristics of damage, costs per equipment repair and/or complete replacement and certainly impact of undertaken management decisions.

Risk management [7,8] comprises the following stages:

1. Risks identification – determination of probabilistic risks, which have direct influence on power supply system operability.
2. Risks assessment and analysis – qualitative and quantitative analysis of occurrence probability of critical and potentially hazardous emergency situations in electrical mains.
3. Creation of control action – determination of measures for complete prevention of potentially hazardous emergency situation, or, in case of no possibility of these measures implementation, reduction of negative consequences of probabilistic failure (emergency).
4. Monitoring – risks monitoring, determination of latent risks, evaluation of risks elimination and minimization consequences.
5. Control and management – performing of scheduled actions in accordance with evaluation of risks elimination and minimization efficiency in case of feedback for planning and management decisions making concerning impact on electric power system.

Certainly, the present approach can be implemented, firstly, on the base of reliable and sufficient information about electrical mains objects state and its network-operating parameters [9,10] and, secondly, with the use of intelligent techniques for data processing and analysis and technical management decisions making . Risks are probabilistic events, for their identification it is required to know causes of their occurrence – definite non probabilistic factors. Determinacy, certainty and completeness of factor space, which contains information about electric mains' engineering objects and their operation modes, are required for transition to a new strategy in engineering policy control in power grid facility for its efficiency improvement.

III. ECONOMIC EFFICIENCY DETERMINATION OF AUTOMATED ACTUAL STATE EVALUATION SYSTEM IMPLEMENTATION

According to prudent estimate for power equipment diagnostics results processing during 3 months 3 employees labor was required for implementation of automated actual state evaluation system in power grid plant in mid-sized electric generation system. After implementation of such intelligent system labor costs are reduced – only one employee labor is required for system maintenance, and time for results processing is less than 1 calendar month.

Besides labor costs, calculation equipment cost and burden costs (stationary and administrative expenses) are also considered. In this case conditional annual saving of plant will be more than 1.5 million rubles, and economic potential will be not less than 1.1 million rubles (Table 1) [11].

The case is considered, when plant develops its own automated complex. Time required for development is assumed equal 6 months, time for product implementation and staff training is 2 weeks. In this case costs for the present system creation will be nearby 1.9 million rubles. This estimate is also prudent. In case of automated system development by external company its cost will be higher.

According to [12] efficiency of presented system implementation was evaluated by methods, which can be divided into 2 main groups: statistical (based on discount rates) and dynamical (based on discounted estimates) methods of project efficiency evaluation. Let us consider them in detail.

Statistical indexes of efficiency assessment comprise payment back period and investment return factor. Investment return factor can be calculated by the following:

$$ARR = \frac{E_a}{C}, \qquad (1)$$

where E_a – expected conditional annual saving, C – cost value for system development and implementation.

From here expected payment back period can be calculated as follows:

$$PP = \frac{1}{ARR}. \qquad (2)$$

It was found that actual payment back period is 1,3 years, and investment return factor is 0,79. It is obvious that time of investment return is rather short and therefore sufficient negative effect in the short run and in the long run is not expected in case of automated system implementation.

The following dynamic efficiency factors can be distinguished: net present value (NPV), productivity index (PI), internal rate of return. NPV is calculated as follows:

$$NPV = E_a \cdot \sum_{t=1}^{T_n} \frac{1}{(1+E)^t} - C, \quad (3)$$

where E_a – expected conditional annual saving, C – cost value for system development and implementation, E – constant discount rate, T_n – normative payback period. Productivity index is calculated by the following formula:

$$PI = \frac{1}{C} \cdot \sum_{t=1}^{T_n} \frac{E_a}{(1+E)^t}. \quad (4)$$

It is seen that NPV for accepted normative payback period (5 years) is more than 3.7 million rubles, and PI is well above 1 – therefore investments in projects are economically sound. Discounted payment back period will be 3,25 years, it can be defined in accordance with formula 5.

$$DPP = \min T, \text{where} \sum_{t=1}^{T} \frac{E_a}{(1+E)^t} \geq C. \quad (5)$$

Calculated parameters of automated system implementation efficiency are presented in Table 1.

Table 1. Efficiency parameters of automated system implementation for electrical mains objects' actual state assessment

Parameter		value	
Labor costs	Before implementation	2032120 rub. / year	58061 $/ year
	After implementation	671260 rub. / year	19179 $/ year
Costs for PC operation, stationary and administrative expenses etc.	Before implementation	373696 rub. / year	10677 $/ year
	After implementation	174233 rub. / year	4978 $/ year
Total costs	Before implementation	2407816 rub. / year	68795 $/ year
	After implementation	845493 rub. / year	24157 $/ year
Cost for development and implementation		1874860 rub.	53567 $
Expected conditional annual saving		1562324 rub. / year	44638 $/ year
Expected annual economic benefit		1187352 rub. / year	33924 $/ year
Net present value		672180 rub.	19205 $
Internal rate of return		29,01%	
Discounted payment back period		3,25 years	

Implementation of automated control systems with on-line diagnostics functions on the base of microprocessor units allow in-time faults detection and reducing of emergency failures probability thanks to determination of fault growth initial stage. In case of formalized faults the present systems allow reduction of costs for repair works due to taking measures based on actual equipment state instead of preventative and predictive maintenance. Undertaken studies show that in case of well-functioning system of automated assessment of power equipment actual state, operating expenses for maintenance of electric mains power equipment, being in risk group, are reduced by 6% in the medium term.

Studies concerning power transformers' failures [13] show that power transformers are referred to risk group by operational life being more than 25 years thereby exceeding standard operational life. Number of failures on early stages, mainly related to design and production faults, is rather small, it is less than 2% [13] from the total failures number. With operational life increase fault probability rises sharply.

For evaluation of production resources use efficiency in case of implementation of automated system, based on Yekaterinburg (Russia) power supply system, statement of costs for maintenance of 110 kV power transformers, being in risk group, was performed.

Table 2. Assessment of economic efficiency of automated system for power transformers diagnostics

Parameter		Value	
Number of 110kV power transformers		124 it.	
Power transformers cost		3213000 thousand rubles	91800,0 thousand $
Total costs for current repairs and maintenance		89964 thousand rubles per year	2570,4 thousand $
Costs for current repairs and maintenance of transformers referred to risk group	Before implementation	54878 thousand rubles per year	1567,9 thousand $
	After implementation	3293 thousand rubles per year	1473,9 thousand $
Annual effect from automated system use		3293 thousand rubles	94,1 thousand $

Calculation results are as follows: even with consideration of a set of assumptions and inaccuracies, efficiency of automated system implementation for power equipment actual state assessment in maintenance services of power grid plants is very high. Therewith taking into consideration possibility of developed system duplication, in future the cost for its implementation on other electricity generation facilities will be considerably lower.

Considering general economic beneficial effect from well-timed power equipment maintenance (and increase of its operation lifetime), implementation of the present automated system for power equipment actual state assessment will produce great economic effect, which will not only improve enterprise productivity and competitive capacity but also provide substantial accuracy increase of electrical mains objects' actual state assessment.

In long term prudent estimate, presented in Table 2, will allow building system for emergency shutdowns minimization in power supply system. It should be mentioned that efficiency is achieved not only by costs reduction for power equipment current repairs and maintenance but also by means of improvement of consumers power supply reliability.

IV. Conclusions

Developed automated system for assessment of electrical mains objects' actual state is designed for base formation for new generation electrical mains creation. The present system is based on adaptivity principle for multicriterion problems solving on the base of nonuniform information, which in many cases is unreliable.

Performed analysis of different approaches to operational activity arrangement proves obvious advantage of electrical mains objects control by their state with the future use of risks management, for which, certainly, absolutely reliable and complete information with sufficient information redundancy is required. Modern intelligent techniques, amount of data about objects state etc. make the similar projects implementation possible.

Performed assessment of economic efficiency rather clearly illustrates appropriateness of automation facilities implementation in information environment of power supply plants and economic benefit from implementation of automated system for assessment of electric mains objects' actual state. Creation of equipment state assessment system is the first step for risks management system building in integrated power grid.

References

[1] *Policy of innovation-driven growth, energy saving and improvement of energy efficiency of OJSC "Rosseti"* [Online]. Available: http://www.mrsk-1.ru/common/upload/docs/policy_2705.pdf).

[2] H. Tanaka, S. Tsukao, D. Yamashita, T. Niimura. *Multiple Criteria Assessment of Substation Conditions by Pair-Wise Comparison of Analytic Hierarchy Process.* Power Delivery, IEEE Transactions on (Volume:25 , Issue: 4), 2010, pp. 3017-3023.

[3] S. A. Gusev, O. M. Kotov, V. P. Oboskalov. *Meshed power system reliability assessment techniques.* WIT Transactions on Ecology and the Environment, 2014, pp. 235-247.

[4] A. I. Khalyasmaa, S. A. Dmitriev, S. E. Kokin. *Assessment of power transformers technical state based on technical diagnostics*. Applied Mechanics and Materials, 2014, vol. 492. pp. 218-222.

[5] A. I. Khalyasmaa, S. A. Dmitriev, S. E. Kokin, D. A. Glushkov, P.A. Kuzin. *Development of 110-220 kV power transformer model for equipment functional state assessment system*. Advanced Materials Research, 2014, vol. 960-961, pp. 1347-1351.

[6] A. I. Khalyasmaa, S. A. Dmitriev, S. E. Kokin. *Monitoring and diagnostics systems application at 35-110 kV substation*. Advanced Materials Research, Vol. 694-697, 2013, pp. 1329-1333.

[7] Scott Berkun. *The art of project management.* , O'Reilly, 2005, 400 p.

[8] Liu Ke, Jie Chen, Shen Xiaoliu, Tan Zhongfu, Shen Yangshuo. *Risk Management with Risk Chain in Electric Power Company*. Electrical and Control Engineering (ICECE), 2010 International Conference on, 2010, pp. 5562-5565.

[9] P. I. Bartolomey, S. A. Eroshenko, S. I. Semenenko, A. A. Suvorov. *PMU-based informational support of power system control tasks*. WIT Transactions on Ecology and the Environment, 2014, pp. 307-318.

[10] A. V. Pazderin, E. S. Kochneva. *Bad data validation on the basis of a posteriori analysis* . ENERGYCON 2014 - IEEE International Energy Conference, 2014, pp. 386-391.

[11] H. J. Bierman, S. Smidt. *The Capital Budgeting Decision.* Ninth Edition: Economic Analysis of Investment Projects. (Taylor & Francis Group, UK 2006), [Online]. Available: http://samples.sainsburysebooks.co.uk/9781135656164_sample_533394.pdf.

[12] Methodical journal «Bank crediting» №6, 2008, Publishing house «Reglament», Moscow.

[13] William H., Bartley P.E. *Analysis of transformer failures*. International association of engineering insurers. 36-th Annual conference – Stockholm, 2003, 13 p.

[14] W. C. Flores, E. E. Mombell, J. A. Jardini: *Expert system for the assessment of power transformer insulation condition based on type-2 fuzzy logic systems*, vol. 38, 2011, pp. 8119-8127.

Evaluation of Latvian Rural Development Programme Measures with Propensity Score Matching

Juris Hazners (corresponding author)
Department of the Evaluation of Rural Development Programme
Latvian State Institute of Agrarian Economics
Riga, Latvia
juris@lvaei.lv

Elita Benga
Department of the Evaluation of Rural Development Programme
Latvian State Institute of Agrarian Economics
Riga, Latvia
elita@lvaei.lv

Armands Veveris
Department of the Evaluation of Rural Development Programme
Latvian State Institute of Agrarian Economics
Riga, Latvia
armands@lvaei.lv

***Abstract*— The evaluation of EU Member States' co-founded programmes was assigned particular importance in recent years. The significance of the monitoring and evaluation has been confirmed in the European Community Agenda in 2000. Periodic evaluation of EU Member States Rural Development Programme (RDP) specific policy interventions is considered crucial in policy development. The core question to be answered in programme evaluation is whether the stated objectives are accomplished by particular intervention. Until recently, use of „naïve" estimates was common in the evaluations of EU Member States Rural Development Programmes. Use of these estimates leads to potentially substantial selection bias resulting from using the outcomes of non-participants as proxy for the possible outcomes of participants in the case of non-participation. The effectiveness of interventions on outcomes of interest can be better evaluated either by propensity score matching (PSM). The objective of the study is to determine the net average effects from farm investment support measure of the Latvian Rural Development Programme 2007-2012. To reach the research objective, propensity scores based on the most important characteristics were calculated for participants and non-participants of the measure and average treatment effects for gross revenues, gross turnover and gross value added were evaluated by matching methods. The research results show that the positive programme effects evaluated by "naïve" estimators are overestimated in comparison with the results obtained by more rigorous PSM method.**

Keywords—policy evaluation, rural development programme, propensity score matching, treatment effects

I. Introduction

The evaluation of EU Member States' co-founded programmes was assigned particular importance in recent years. The significance of the monitoring and evaluation has been confirmed in the European Community Agenda in 2000. Periodic evaluation of EU Member States Rural Development Programme (RDP) specific policy interventions is considered crucial in policy development. The main reasons for the evaluation of specific policy interventions are the assessment of a programme's impact, the improvement of programme management and administration, identification of necessary improvements in the delivery of interventions and meeting the accountability. According to the EU definition, programme evaluation is a process that culminates in a judgment (assessment) of policy interventions according to their results, impacts and the needs. In the case of rural development (RD) programmes, EU regulations distinguish between ex-ante, midterm, ex-post and ongoing evaluations. The existing study is considered a part of an ongoing evaluation which would provide the grounds for the ex-post evaluation of Latvian Rural Development Programme 2001-2012.

The core question to be answered in programme evaluation is whether the stated objectives are accomplished by particular intervention (support or „treatment" provided to programme participants). The main problem in the process of evaluation is the assessment of the counterfactual outcome by modelling the situation where treatment is absent. The counterfactual outcome has to be estimated by statistical methods as it is usually not observed, unless there exists a rather costly possibility to use the experimental evaluation with random treatment assignment. Moreover, a random assignment has to be implemented before the policy intervention.

Until recently, use of „naïve" estimates was common in the evaluations of EU Member States Rural Development Programmes. These included „before - after" or „with-without" approaches along with the comparisons with national averages. The „before - after" approach attributes the entire effect of the observed change in particular indicator to the programme support. Thus the real effects may become understated or overstated. The „with - without" technique assumes that the outcome indicators will be the same both for programme participants and non-participants in the absence of the programme support. This leads to potentially substantial selection bias resulting from using the outcomes of non-participants as proxy for the possible outcomes of participants in the case of non-participation. Naïve standard DID (difference in difference) estimator compares the before-and-after changes of selected result indicators for programme participants with the before-and-after changes of the same

ISBN: 978-1-61804-255-2

indicators for arbitrarily selected non-participants. The crucial assumption justifying this method is that selection bias remains time invariant, and this is not often the case. If trends in the outcomes are not time invariant, the estimation is not correct.

II. Materials and Methods

The effectiveness of interventions on outcomes of interest can be evaluated either by regression methods or propensity score matching (PSM). Multiple regression is the most common method for estimating the programme support effect. However, regression cannot take into account the distribution overlap on selected covariates. In many empirical studies, the causal effects are estimated by regressing variable of the outcome of interest on binary treatment variable. Thus the adjustment for the distribution between the treatment group and control group is not provided. PSM is a rigorous non-experimental method. The data for PSM usually are pooled in a panel both from programme participants and non-participants. The non-participating or „untreated" units constitute the „control" group while participants are included in „treatment" group. The information from control group is used to assess what would be the outcome of interest for participants in the absence of the programme. The difference in outcomes for both groups is evaluated by comparison of relatively similar units in these groups. This helps to avoid the potential biases that may arise by comparing the units with substantial differences in their characteristics, as these might affect the participation in the programme and outcomes of interest. A simple comparison of the difference between the averages of the outcome variables in two groups might lead to biased estimation, as the distributions of the covariates in the two groups may differ. A subclassification method was proposed by Cochran (1968) [2]. The observation variable is split into a number of subclasses. The treatment effect is then estimated by comparing the weighted means of the outcome variable in each subclass. Cochran's research suggests that stratifying into five subclasses can remove much of the bias. However, as stated by Rubin (1997) [13], subclassification may turn to be complicated if many covariates exist. To successfully mitigate the potential bias, unit matching has to be based not on a single or a few characteristics but on a full range of available covariates that have potential impact. The propensity score is then defined as the probability of receiving the treatment by the given unit. Thus the matching is reduced to a single variable, and matching on entire set of covariates is no longer necessary.

The method was developed by Rosenbaum and Rubin (1983) [10]. They introduced balancing score as a function of covariates that provides the same distributions of covariates in both groups. Furthermore, they also introduced the assumption of strong ignorability, which implies the same distributions of the covariates in both groups given the balancing scores. They proved that treatment assignment is strongly ignorable if it satisfies the conditions of unconfoundedness and overlap. Unconfoundedness means that conditional on observational covariates, potential outcomes for two groups are not influenced by treatment assignment. The overlap assumption means that with given covariates, the unit with the same covariate values has positive and equal opportunity of being assigned to the treated group or the control group. As stated by Joffe and Rosenbaum (1999) [7], these assumptions eliminate the systematic, pretreatment, and unobserved differences between the units in treatment group and control group. PSM would provide biased estimation of causal effects when assumption of strong ignorability is violated. As suggested by Imbens (2004) [6], if the treatment assignment is strongly ignorable PSM can be used to remove the difference in the covariates' distributions between the treatment group and control group. He suggests four step procedure for implementing the PSM:

1. selection of observational covariates and estimation of propensity scores,

2. stratification of propensity scores and testing of balancing properties in each block,

3. calculation of the Average Treatment on Treated (ATT) by matching,

4. sensitivity test for robustness of estimated ATT effects.

If the balancing properties of covariates are not satisfied in all strata, the test has to be repeated with different number of strata. If the balancing properties are not satisfied again, estimation of propensity scores has to be repeated with modified list of covariates by adding higher order (squared) covariates. After getting all covariates balanced in every stratum, causal effects can be estimated by nearest neighbor matching (NNM), radius matching (RM), kernel matching (KM) or stratified matching (SM).

NN matching computes the ATT by finding the unit in the control group whose propensity score is nearest (absolute value of difference is minimal) for every unit in treatment group. Larger number of comparison units from control group decreases the variance of the estimator. At the same time, the bias of the estimator increases. Furthermore, one needs to choose between matching with replacement and matching without replacement (Dehejia and Wahba, 2002) [4]. When there are few comparison units, matching without replacement will force us to match treated units to the comparison ones that are quite different in propensity scores. This enhances the likelihood of bad matches (increase the bias of the estimator), but it could also decrease the variance of the estimator. Thus, matching without replacement decreases the variance of the estimator at the cost of increasing the estimation bias. In contrast, because matching with replacement allows one comparison unit to be matched more than once with each nearest treatment unit, matching with replacement can minimize the distance between the treatment unit and the matched comparison unit. This will reduce bias of the estimator but increase variance of the estimator.

In RM, the units in both groups are matched when the propensity scores in control group fall in the predefined radius of the units in treatment group. The larger the radius is, the more matches can be found. More matches typically increase the likelihood of finding bad matches, which raises the bias of the estimator but decreases the variance of the estimator.

In KM, all units in treatment group are matched with the weighted average of all units in control group. The weights are determined by distance of propensity scores, bandwidth parameter and a kernel function. Choosing an appropriate bandwidth is crucial because a wider bandwidth will produce a smoother function at the cost of tracking data less closely. Typically, wider bandwidth increases chance of bad matches so that the bias of the estimator will also be high. Yet, more comparison units due to wider bandwidth will also decrease the variance of the estimator.

In SM, for each block the average differences in the outcomes of the treatment group and the matched control group are calculated. The ATT is then estimated by the mean difference weighted by the number of treated cases in each block. With respect to organizational research, Li (2012) [8] recommends stratified matching as it does not require choosing specific smoothing parameters. The estimation of the ATT then from requires minimum statistical knowledge. He regards SM as producing a reliable ATT while being relatively simple. In general, selection of the matching technique is empirical and it largely depends on the results obtained. As proven by Dehejia and Wahba (2002) [4], similar results with most matching methods are obtained when the overlap in the distribution of propensity scores between the treatment group and control group is substantial. After the estimation of the ATT, the sensitivity test is used to investigate whether the causal effect estimated from the matching is susceptible to the influence of unobserved covariates. In detecting the existence of significant unobservables, Rosenbaum (1987) [11] suggested use of multiple comparison groups. Such groups can be used in matching with the treatment group to calculate multiple treatment effects. Comparison of sizes of these effects would provide a sense of the reliability of the estimated ATT. A number of treatment groups can be compared with each other. Comparison of two control groups is possible, too.

The assumption of strong ignorability can be considered violated if causal effects prove to be statistically different between these two control groups. As multiple comparison groups are usually not available, there are three commonly used approaches with respect to sensitivity testing. The first method proposed by Dehejia and Wahba (1999) [3] is changing the specification of the equation by adding or dropping higher order variables. Propensity scores are then recalculated and newly obtained causal effect is compared to the originally computed effect. Such comparison reveals the reliability of originally computed causal effect. Instrumental variable (IV) method is another technique to assess the bias of the causal effects from original results. However, this method generally reduces the efficiency of the estimator. The bounding approach proposed by Rosenbaum (2002) [12] assumes testing of possible hidden bias in the estimation of treatment effect. The test results would provide the level of sensitivity to hidden biases related to unobserved covariates. Such biases can influence the odds of treatment assignment.

The PSM method first has been empirically applied by Heckman, Ichimura, Smith and Todd (1998) [5] in the estimations of training programmes on future income in the USA labor market. Subsequently, similar studies on the USA labor market were carried out by Dehejia and Wahba (2002) [4], and a few other researchers.

The modules for calculating propensity scores and matching for use in STATA software were developed by Becker and Ichino (2002) [1]. Before running the set of necessary modules they recommend to „clean up" the dataset. It is common first to run the *pscore* module which estimates the propensity scores and tests the satisfying of the balancing properties. If the balancing properties are satisfied then ATT can be estimated with one or more of the *att** modules. The modules *attnd* or *attnw*, *attr*, *attk* and *att*s assume nearest neighbor, radius, kernel and stratified matching, respectively. After the calculation of ATT, the module *mhbounds* developed by Rosenbaum (2002) [12] provides sensitivity analysis with Rosenbaum bounds with Mantel and Haenszel (1959) [9] test statistic.

III. Results and Discussion

The data on participants and non-participants of Farm Investment Support Measure of Latvian Rural Development Programme farm investment support measure are sourced form FADN database which is not publicly available. The economic data in the database include all relevant information on programme participants and non-participants regarding their structure and performance from 2007 to 2012. First, as the information should cover periods before and after the implementation of the programme, 606 units were selected out of total number of 943 units. Then further 87 units were dropped because of receiving support only after 2010. For these units, treatment effect is considered unlikely to occur until the end of period. It has left 519 units constituting the data panel. There were 228 units in treatment group, leaving 291 units for possible controls. In total, 39 variables related to unit structure were selected for use in matching process. Three variables for the evaluation purposes were calculated as differences in values of Net Turnover, Gross Revenues and Gross Value Added after and before the implementation of the programme using the „naïve" difference-in-differences estimator. The values of changes in economic variables and calculated treatment effects are shown in Table I.

TABLE I. AVERAGE CHANGES IN MAJOR CHARACTERISTICS OF UNITS SUPPORTED (T=1) AND NON-SUPPORTED (T=0) BY FARM INVESTMENT SUPPORT MEASURE OF LATVIAN RDP DURING THE PROGRAMME (2007-2012)

Number of Units	Gross Revenues (EUR)	Net Turnover (EUR)	Gross Value Added (EUR)
T=1 (228)	110,596	42,932	280,536
T=0 (291)	17,040	2,361	68,381
ATT	93,556	40,571	212,155

Source: research findings, Latvian FADN database

The ATT effect on programme participants calculated by DID method is positive for all three economic characteristics. For programme participants and non-participants, 39 variables considered critical for comparability of economic performance between units were selected. Although only 11 and 15 variables were statistically significant at 5% and 10% level, respectively, dropping the variables with lower significance levels caused a loss of balancing properties in one or more blocks. Similarly, adding of higher order covariates caused the loss of balancing properties. Therefore, the original specification of logit function was preferred. A list of structural

ISBN: 978-1-61804-255-2

variables with their propensity scores obtained with Logit equation is provided in Table II.

TABLE II. RESULTS OF ESTIMATION OF LOGIT FUNCTION

Description	Coefficient	z	P>|z|
Economic size category	0.319782	1.98	0.048
Organic farming	-0.044413	-0.14	0.887
Labor inputs in full time equivalent	-0.528292	-4.94	0.000
Agricultural land	-0.000446	-0.09	0.925
Average	0.004163	1.09	0.277
Output	0.001554	2.35	0.019
Output in crop farming	-0.000003	-0.31	0.757
Other agricultural output	-0.000309	-0.76	0.449
Total agricultural output	0.000079	1.42	0.156
Processing	0.000071	1.21	0.228
Output in forestry	0.000039	0.45	0.653
Output from other areas	0.000056	0.91	0.361
Net turnover	0.000017	1.66	0.097
Total intermediate consumption	-0.001667	-2.52	0.012
External costs	-0.000039	-0.75	0.453
Gross revenue	-0.001670	-2.51	0.012
Gross value added	-0.000015	-2.26	0.024
Net value added	0.000051	1.75	0.081
Net value added on labor unit	-0.000035	-1.64	0.102
Gross margins in crop farming	0.000046	0.68	0.496
Gross margins in livestock farming	-0.000079	-1.17	0.242
Total assets	0.000004	1.15	0.248
Buildings	-0.000006	-1.14	0.254
Equipment and machinery	0.000001	0.17	0.868
Total liabilities	-0.000005	-1.09	0.277
Short-term liabilities	0.000000	-0.01	0.988
Gross investments	-0.000012	-1.79	0.074
Total state support	0.001703	2.6	0.009
Area payments	-0.000334	-1.88	0.060
Less favorable area payments	0.000113	1.44	0.149
Subsidies for livestock farming	-0.000029	-0.48	0.628
Other subsidies	0.000060	0.72	0.470
Compensated excise tax	0.000589	3.12	0.002
Subsidies for investments	-0.001620	-2.48	0.013
Total taxes paid	-0.000234	-0.95	0.341
Wage tax paid	-0.001861	-3.53	0.000
Social tax paid	0.001808	4.15	0.000
VAT paid	0.000270	1.09	0.276
Income tax paid	0.000858	1.26	0.206

Source: research findings, Latvian FADN database

The Table III shows the inferior bound, the number of treated units and the number of control units for each of iterated five blocks.

TABLE III. BLOCKS OF PROPENSITY SCORES

Inferior of block of propensity score	T(0)	T(1)	Total
0.0403895	151	26	177
0.2	74	24	98
0.4	25	35	60
0.6	14	35	49
0.8	7	108	115
Total	271	228	499

Source: research findings, Latvian FADN database

The common support option has been selected. This restriction implies that the test of the balancing property is performed only on the observations whose propensity score belongs to the intersection of the propensity scores in both groups. With the given specification the balancing property is satisfied. The results of evaluation of average treatment effects with various matching methods and respective test statistics are shown in Table IV.

TABLE IV. AVERAGE TREATMENT EFFECTS ON ECONOMIC VARIABLES BY METHOD, EUR AND TEST STATISTICS

Method		NN	RM-0.01	KM	SM
Treated		228	132	228	221
Controls		69	257	271	271
Gross Revenues	ATT	35,385	25,164	39,129	34,923
	t	0.85	3.03	3.67	4.29
Net turnover	ATT	63,638	38,324	48,325	46,113
	t	0.68	3.12	1.62	1.55
Gross Value added	ATT	125,000	77,385	134,000	109,000
	t	0.68	2.44	3.90	2.85

Source: research findings, Latvian FADN database

The estimated values of average treatment effects for all three variables with radius matching methods at smaller radius than 0.01 yielded statistically insignificant results. Moreover, the number of selected units was very low. The average treatment values with the highest test statistics were considered the best estimates for economic variables. Sensitivity analysis was carried out using the Rosenbaum bounding approach. The results show that the estimated effects of the Farm Support Measure are rather sensitive. On all three economic variables, the sensitivity test shows that a hidden bias which increases the odds ratio from 1 to 1.05, would make the obtained results statistically insignificant. The relatively high sensitivity would have been caused by relatively small number of observations in control group. It is recommended to have up to 4 times more observations for potential controls which is not the case. However, the results of sensitivity tests are providing only additional information with respect to the calculated effects' stability. The overall validity of the obtained results is not questioned.

The values obtained with the propensity score method along with their respective values from „naïve" estimation are shown in Table V.

TABLE V. COMPARISON OF THE RESULTS OBTAINED WITH „NAÏVE" ESTIMATION AND PROPENSITY SCORE MATCHING

Method	Gross Revenues (EUR)	Net Turnover (EUR)	Gross Value Added (EUR)
„Naïve" estimation	93,556	40,571	212,155
Propensity score matching	34,923	38,324	134,000

Source: research findings, Latvian FADN database

The values of changes in economic variables obtained by „naïve" difference-in-differences estimator are higher than those yielded by propensity score matching. This indicates to a possible overestimation of programme effects.

IV. CONCLUSIONS

Use of „naïve" estimators in evaluation of programme effects on economic variables can lead to the overestimation of changes in economic variables attributed solely to the programme. Propensity score matching has to be considered a more suitable method in establishing a sound counterfactual.

REFERENCES

[1] Becker, S. and Ichino, A. (2002). Estimation of average treatment effects based on propensity scores. *The Stata Journal, 2*, pp. 358-377

[2] Cochran, W. (1968). The effectiveness of adjustment by subclassification in removing bias in observational studies. *Biometrics, 24*, pp. 295-313

[3] Dehejia, R. and Wahba, S. (1999). Causal effects in nonexperimental studies: Reevaluating the evaluation of training programs. *Journal of the American Statistical Association, 94*, pp. 1053-1062

[4] Dehejia, R., & Wahba, S. (2002). Propensity score-matching methods for nonexperimental causal studies. *Review of Economics and Statistics, 84*, pp. 151-161

[5] Heckman, J.J., Ichimura, H., Smith, J. and Todd, P. (1998), Characterizing Selection Bias Using Experimental Data, *Econometrica, 66(5)*, pp. 1017-1098.

[6] Imbens, G. W. (2004). Nonparametric estimation of average treatment effects under exogeneity: A review. *The Review of Economics and Statistics, 86*, pp. 4-29

[7] Joffe, M. M., & Rosenbaum, P. R. (1999). Invited commentary: Propensity scores. *American Journal of Epidemiology, 150*, pp. 327-333

[8] Li, M. (2012) Using the Propensity Score Method to Estimate Causal Effects: A Review and Practical Guide. *Organizational Research Methods, 00(0*) pp. 1-39

[9] Mantel, N. and Haenszel, W. (1959), Statistical Aspects of the Analysis of Data from Retrospective Studies of Disease, *Journal of the National Cancer Institute 22(4)*, pp. 719-748.

[10] Rosenbaum, P. R., & Rubin, D. B. (1983). The central role of propensity score in observational studies for causal effects. *Biometrika, 70*, pp. 41-55

[11] Rosenbaum, P. (1987). The role of a second control group in an observational study. *Statistical Science, 2*, pp. 292-306

[12] Rosenbaum, P.R. (2002), *Observational Studies*, New York: Springer, 2nd edition

[13] Rubin, D. (1997). Estimating causal effects from large data sets using propensity scores. *Annals of Internal Medicine, 127*, pp. 757-763

[14] Smith, J. and Todd, P. (2005), Does Matching Overcome LaLonde's Critique of Non Experimental Estimators?, *Journal of Econometrics 125(1-2)*, pp. 305-353

ISBN: 978-1-61804-255-2

Briquetting of Metal Chips by Controlled Impact: Experimental Study

Todor Penchev, Ivan Altaparmakov, Dimitar Karastojanov

***Abstract*—**For briquetting of metal chips are used hydraulic and mechanical presses. The density of the briquettes in this case is about 60% - 70 % on the density of solid metal. In this work are presented the results of experimental studies for briquetting of metal chips, by using a new technology for impact briquetting. The used chips are by Armco iron, steel, cast iron, copper, aluminum and brass. It has been found that: (i) in a controlled impact the density of the briquettes can be increases up to 30%; (ii) at the same specific impact energy Es (J/sm^3) the density of the briquettes increases with increasing of the impact velocity; (iii), realization of the repeated impact leads to decrease of chips density, which can be explained by distribution of elastic waves in the briquette.

***Keywords*—** briquetting, chips briquetting, impact briquetting.

I. Introduction

FOR briquetting of metal chips are used mechanical and hydraulic presses with a nominal force of several hundreds to several thousands kN. To obtain briquettes with good density the ratio H/D for different materials vary within wide limits (H / D = 0,8-0,25), where H is the height, and D is the diameter of the briquette. The greater is the density of the briquettes, the smaller are the losses in the transport and melting. Basic parameters used to evaluate the effect of briquetting operation are specific density of the briquette (ρ), g/sm^3, and specific contact pressure for briquetting (p), MPa.

At briquetting with hydraulic presses it is achieved 50% - 65% briquette's density in comparison with solid material density. The specific pressure reaches values p = 200-400 MPa, in briquetting of steel chips [1,2].

Due to the large size of briquetting presses, large power consumption, and relatively low productivity, methods are searching to improve the efficiency of this process. One such method is high velocity impact briquetting. This method has been successfully used for working-out of parts from powder materials [3,4].

In [5] are presented the results of use of high velocity explosive presses for briquetting of metal chips – fig.1. The obtained briquette's density is (g/sm^3): aluminum alloy - 2.2 to 2.4 (2.7 to 2.75); carbon steel - 5.0 to 5.5 (7.85); alloyed steel - 5.0 to 5.5 (7.48 to 8.0). In parenthesis is given the density of the respective solid metal. As a major drawback of this briquetting method is the impossibility of process control.

In [6] is described construction of industrial rocket engine propelled die forging hammer. Whit this machine is possible to work with controlled impact and with impact velocities from 4,5 m/s up to 20 m/s

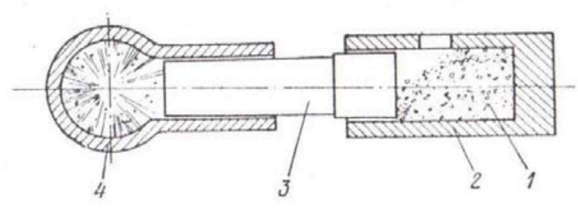


Fig.1. Scheme of explosion press for metal chips briquetting: 1 – filled chips; 2 – container; 3 – punch; 4 - explosion chamber

In [7] are presented the results of experimental study of metal chips briquetting by controlled impact with impact speed of about 7 m/s. In this study are presented the results of laboratory experimental studies for briquetting of metal chips using controlled impact with impact speeds of 4-5 m/s.

II. Laboratory Setup for Controlled Impact Briquetting

The laboratory setup is shown in Fig.2a. Free fall down of falling part 3 is accelerated by cold rocket engine attached to 3. The engine is started up at feeding to it of compressed air with a pressure of 35 bar. The engine force (trust R) at this pressure is 23 kg. From electronic control unit (part No 6 on Figure 2a) can be set four regimes of operation of the engine – Fig. 2b.

III. Method of Experiment

A. Type and material of the chips

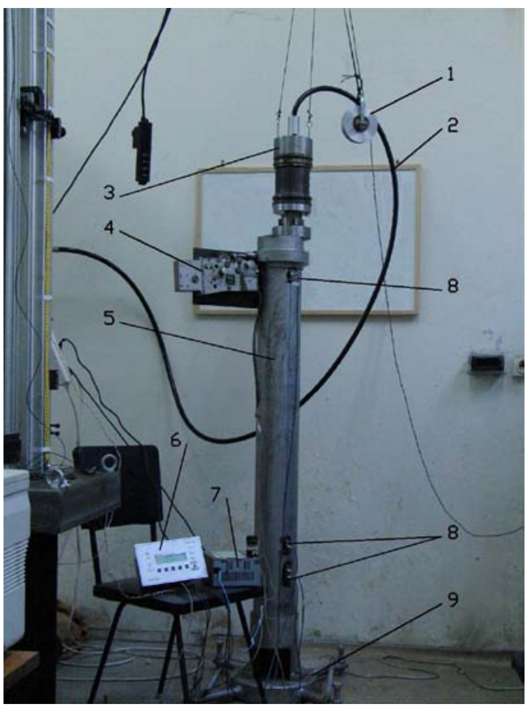
In this study we used chips from the following materials: Armko iron (0,04% C); steel (0.45 % C); gray cast iron (3.25% C); aluminum alloy (0,9% Mn, 1,8% Mg); copper

(99.9%); brass (37% Zn). Brocken ships with small thickness produced by turning are used.

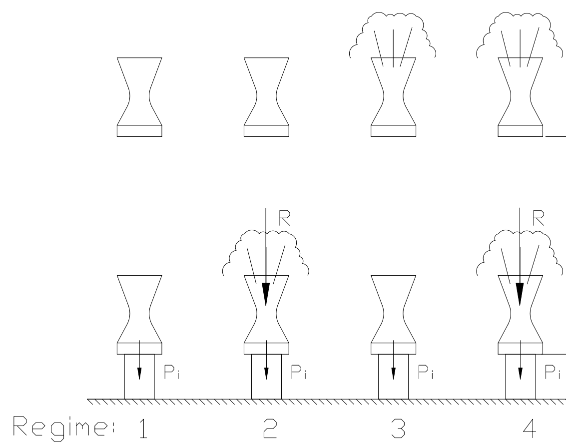
B. Sequencing

For obtaining of briquettes are used two containers with hole diameter of 80 mm and 40 mm. The mass of the falling part is m = 35.67 kg.

On a laboratory scale is measured with an accuracy of 0.01 g the chips mass G, g, and the container is filled. The punch with guide is placed so that the top of the punch touches the chips. Regime 3 and Regime 4 are used (Fig. 2b), at a speed of falling parts 4,1 - 5,3 m/s. Only those experiments are take into account in which the difference in the impact speed ΔV_i for the same amount of material for briquetting by both Regimes is $\Delta V_i \leq \pm 2\%$.



a)



b)

Fig.2. a) Laboratory setup: 1 – hose support roller; 2 – hose for pressure air feed; 3 – falling part; 4 – system for hold up of the falling part in upper position; 5 – tube body; 6 – electronic control unit; 7 – power supply of system 4; 8 – inductive sensors; 9 – base; b) Regimes of the experimental setup: 1 – simple impact; 2 – simple impact + controlled impact; 3 – accelerated by rocket engine simple impact; 4 – accelerated impact + controlled impact; Pi – impact force; R – rocket engine trust

After the impact the briquette is removed and the briquette height Hbr is measured. Determine the impact velocity V_i, m/s, according to data from the lower inductive sensors 8, located on the tube (Fig.2a). Are calculated: the volume of the briquette Ξ,sm^3; density $\rho = G/\Xi$,g/sm^3; impact energy $E_i = mV_i^2/2$,J; specific impact energy for briquetting E_s

$$E_s = E_i / \Xi, J / sm^3 \qquad (1)$$

Specific energy E_s instead specific pressure p is used, because the main parameter for hammers is the impact energy.

III. Experiments results

A. Briquettes with 80 mm diameter

The first material with which the experiments start was Armko iron. It was found that briquettes are with very low density - ρ=1.6 g/sm^3. The reason for this is the small impact energy, and small specific impact energy E_s=0.60, J/sm^3. To increase the impact energy the briquette was put back into

ISBN: 978-1-61804-255-2

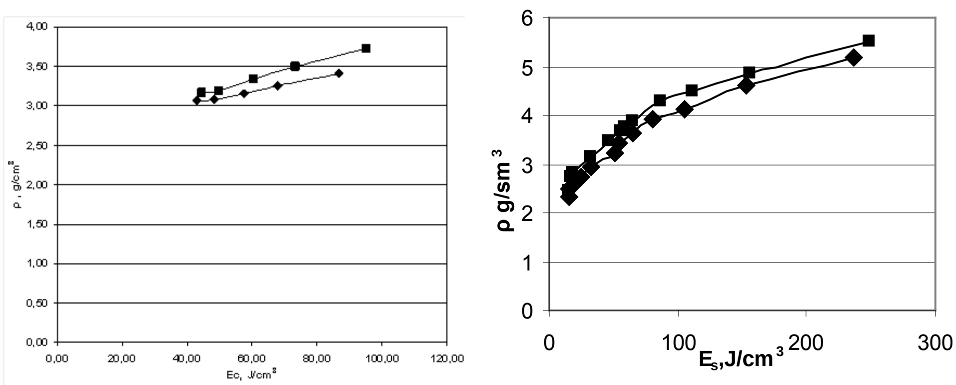
container and second impact was realized. Instead of increasing a reduction of the briquette density to 0.9 g/sm^3 and briquette loosening was observed - Fig.3.

Fig.3. Briquettes from Armco iron chips with 80 mm diameter: left – after one impact; right – after two impacts

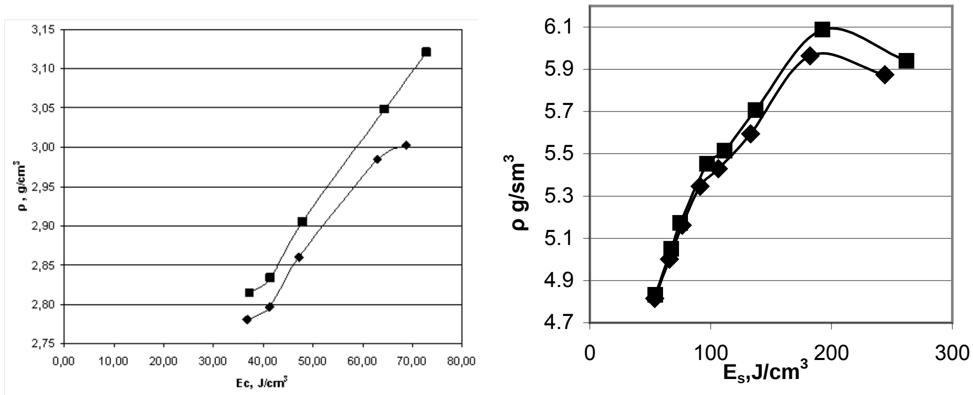
B. Briquettes with 40 mm diameter

The obtained results by 40mm briquettes are presented in fig.4a. For comparison in fig 4.b are presented the results from [7], where the impact velocity V_i and specific impact energy E_s are higher.

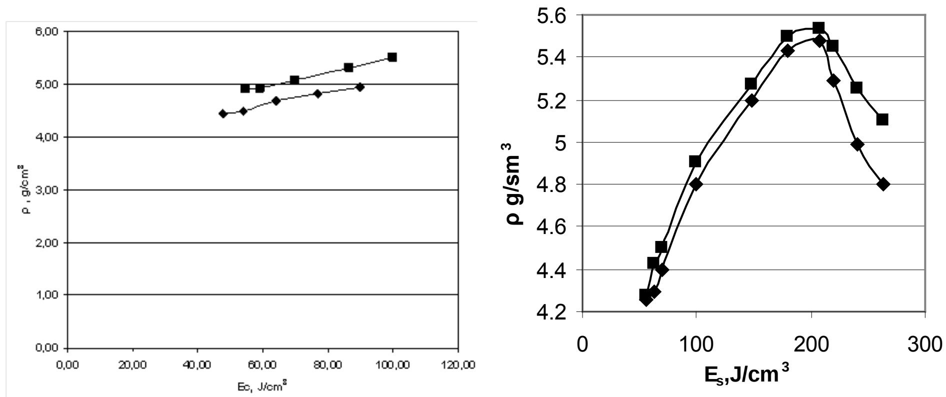
From fig.4a it is seen that in all materials the density of briquettes obtained by controlled impact is higher then the density of the briquettes obtained by simple impact – 7% higher at Armco iron briquettes; 4% at steel briquettes; 8.9% at cast iron briquettes; 5.8% at aluminum alloy briquettes; 6% at cooper briquettes; 6.9% at brass briquettes. Comparison with results by briquetting with high speed at the same specific energy shows (fig.4b) that in all materials, with exception of cast iron, the briquettes density obtained by high impact velocity is much larger.



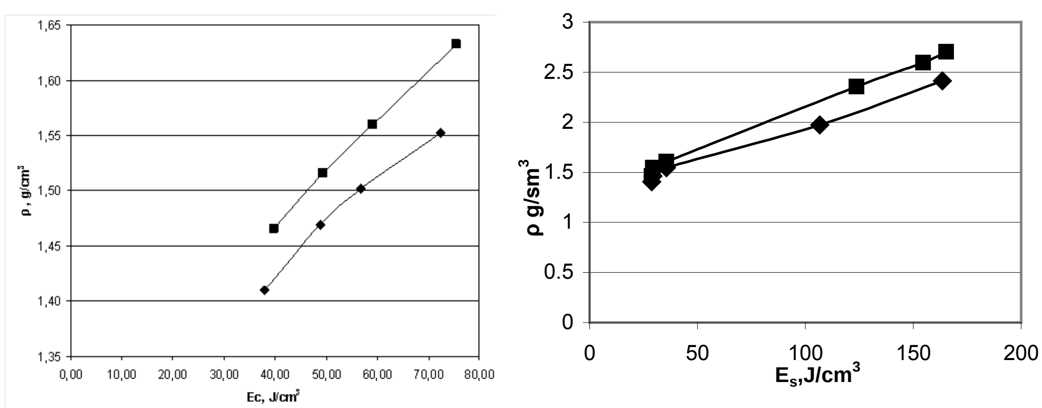
a)


ρ , g/cm3
Ec, J/cm3
ρ g/sm3
Es,J/cm3

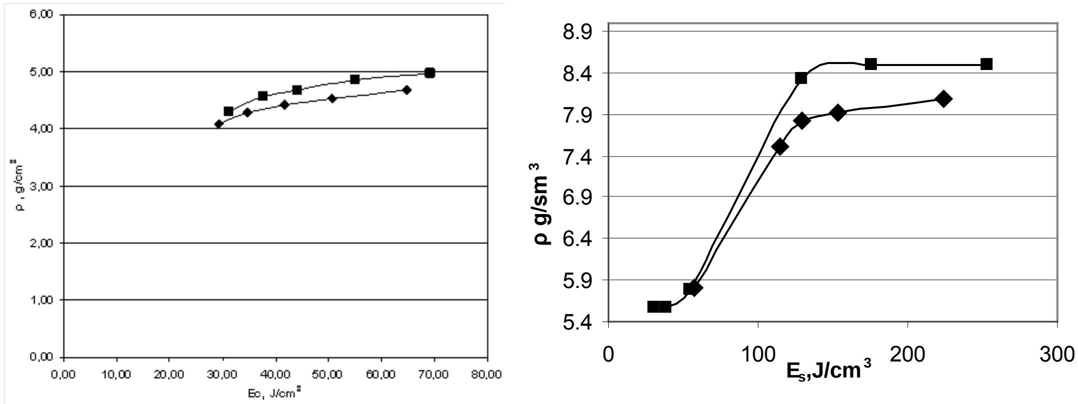
b)


ρ , g/cm3
Ec, J/cm3
ρ g/sm3
Es,J/cm3

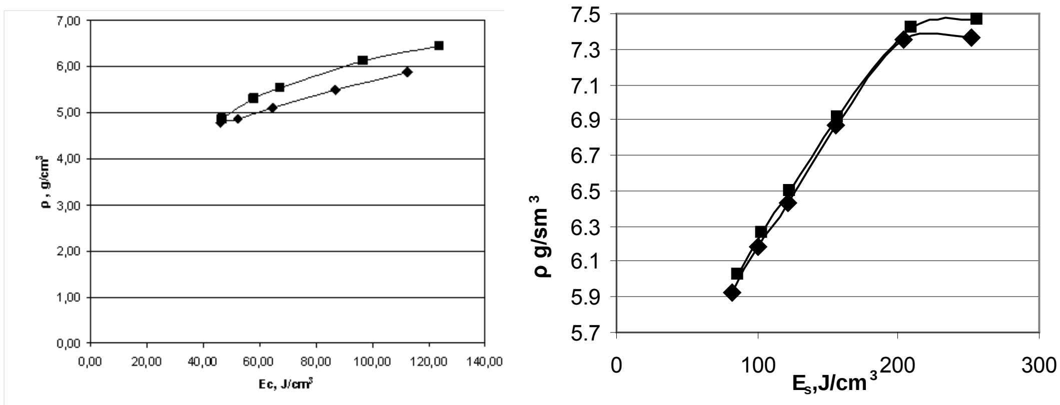
c)


ρ , g/cm3
Ec, J/cm3
ρ g/sm3
Es,J/cm3

d)



e)



f)

Fig.4. Results of impact briquetting with different impact velocities V_i: left- V_i = 4.10-5.32 m/s; right V_i = 6.9-7.16 m/s [7] a) Armco iron; b) steel; c) gray cast iron; d) aluminum alloy; e) pure cooper; f) brass

IV. Conclusion

The following characteristics which distinguish controlled impact briquetting than other types briquetting are established.

• Obtained in this work and in [7] results shows that briquetting of the metal chips with a controlled impact increases the density of the briquettes with up to 30% in comparison with a hydraulic press briquetting.

•The density of the metal chips briquettes obtained by impact depends from the impact specific energy Es, J/sm^3.

• At the same specific energy E_s, the greater is the impact velocity, the greater the density of the briquettes. This applies to all tested materials, except for gray cast iron. For example the density of cooper briquettes ρc obtained by E_s = 70 J/sm^3 (fig.4e) is: ρ_c=5 g/sm^3 , V_i = 4.5 m/s; ρ_c = 6.4 g/sm^3, V_i = 7 m/s.

• When briquetting of grey cast iron chips it can achieve higher density of the briquettes at low impact speed, with the same specific energy E_s – fig.4.2c.

• Realization of the repeated impact leads to decrease of chips density, which can be explained by distribution of elastic waves in the briquette.

ISBN: 978-1-61804-255-2

ACKNOWLEDGMENT

The research work reported in the paper is partly supported by the project AComIn "Advanced Computing for Innovation", grant 316087, funded by the FP7 Capacity Programme (Research Potential of Convergence Regions).

REFERENCES

[1] [1]. Stepanskii L.V., Metal waste briquetting, Mashgis, 1975, (in Russian).
[2] [2]. http://www.johnhartinternational.com/briquetting/
[3] [3]. Poljakov A.P., Zalazinskaja E.A., Impact extrusion of powder material billets, Zvetnaja metallurgia, 2003, 1, 30-35, (in Russian).
[4] [4]. Wang J., Yn H., Qu X., Analysis of density and mechanical properties of high velocity compacted iron powder, Acta Metallurgica Sinica (English Letters), v.22, 6, 2009, 447 – 453.
[5] [5]. Stepanov W.G., Shavrov I.A., High energy impulse methods for metal working processes, Mashinostroenie, 1975, (in Russian).
[6] [6]. P. Bodurov, T. Penchev, Industrial rocket engine and its application for propelling of forging hammers, Journal of Materials Processing Technology, 2005, 161, 504-508.
[7] [7]. T.Penchev, I.Altaparmakov, Experimental Investigations on "Controlled Impact" Effect, International Conference METAL 2013, Brno, 15-17.05.2013.

Todor N. Penchev is a member of the Bulgarian Scientists Association. He was born in Sofia, Bulgaria in 1941. He has a master degree in Mechanical engineering. He graduated Technical University Sofia in 1967. The author received a doctoral degree in 1979, Industrial Technology from the Technical University Sofia. Dr.Penchev is an assoc. professor in Institute of Information and Communication Technologies (BAS). Dr. Penchev is an assoc. professor under AcomIn project at the IICT – BAS. He is conducting research on design, dynamics and mechanics of mechatronic systems and industrial processes. His professional interests refer to forging systems, industrial engineering and technology.

Ivan L. Altaparmakov is born in Kroumov Grad, Bulgaria in 1972. He has a master degree Mechanical engineering. He graduated Technical University Sofia in 1995 and he has a master degree in Applied Mathematics and Informatics. He graduated Technical University Sofia in 1997. The author received a doctoral degree in 2003, Industrial Technology from the Technical University Sofia. Dr. Altaparmakov is assistant professor in Faculty of Applied Mathematics and Informatics at Technical University Sofia and assistant professor in Institute of Information and Communication Technologies (BAS). His professional interests refer to forging systems, industrial engineering and technology, Mathematics, programming.

Dimitar N. Karastoyanov is a member of the Bulgarian Scientists Association. He was born in Stara Zagora, Bulgaria in 1952. He has a master degree in Electrical engineering. He graduated Technical University Sofia in 1977. The author received a doctoral degree in 1982, Robotics from the Institute of engineering cybernetics and robotics (BAS). Dr. Karastoyanov is a professor in Institute of Information and Communication Technologies (BAS). Prof. Dr. Karastoyanov is a key professor under AcomIn project at the IICT – BAS. He is conducting research on design, dynamics and intelligent control of robots and mechatronic systems. His professional interests refer to real time systems, adaptive control, industrial engineering and robotics.

Practical Aspects of Communications Barriers between Czech Managers and African Employees with Focus on Cultural Barriers

Martina Kubíčková, Lenka Smékalová

***Abstract*—**The principal purpose of this paper is to explore the most effective way of managing intercultural communication in teams where Czech managers meet African employees. Empirical findings have highlighted the role of organizational communication for the viability of business effectiveness. Employees present the basic building blocks of organizations and simultaneously firms can improve their performance through better mastered employee communications. Awareness of the basic requirements, necessary communication, and early solution help to prevent conflicts and crises that can adversely affect the success of the whole company. The findings have been compared with the replies of individual respondents and confronted in connection with the theoretical knowledge of the problem at hand. Results have been interpreted on an exploratory basis. A set of principles for improvement of the organizational communications have been designed, based on the major findings.

***Keywords*—** Communication, Communication barriers, African employee, Czech management.

I. Introduction

MANY authors have devoted enormous attention to communication techniques and try to understand why, despite the great efforts, the employee or people generally do not communicate easily and smoothly. The causes of this deficiency shall be so far only argued. Perhaps the core of this problematic is represented by the fact that people must learn to communicate. Reference [14] indicates this issue in their research of communication as one of the major factors leading to success in today's highly competitive environment. This ability manifests itself even more dominantly in the companies with diverse ethnicity of the employees where the common communication barriers intersect with issues of internationalization. A very important idea in this area also constitutes assumption of many authors [6], [12], [11] that the crucial point in the success of multicultural environment companies and their sustainable development is represented by the communicating people [8].

According to reference [21] the importance of communication has increased as a management key element especially in the last decade. The main emphasis is on the fact that the meaning of the communication changes during the communication development. Nowadays communication do not represent only a function of management but first of all the relationship. Some of the authors who support this consideration are Reference [18] shows Porvaznik and Ladová construed the communication as submitting and accepting of the messages among two or more people. This trend of communication was already known in 1999 when Marschan-Piekarri, Welch and Welch emphasized the significance of communication like a relationship that will be crucial to the success of modern companies primarily with a multicultural internal environment [15].

II. Communication barriers in multicultural companies

Authors determine the main communication requirements as the clarity and credibility [18], [1]. Adherence to these principles facilitates the overcoming of communication barriers.

Reference [9] sees communication not only as one of the managerial tools but also as a critically important way to overcome communication barriers and of the way to utilize the potential arising from cultural diversity of employees. Researchers perceive relationships that communication helps to create as completely critical to the success of modern companies [17]. Deficient communication within the enterprise is responsible for up to 60 % of conflicts within the particular enterprise [24].

Reference [4] specifies the two most important barriers as social awareness and the knowledge base of a man and his cultural perceptions. Ultimately, the need to differentiate between the sexes is associated. Reference [16] points out that

The authors are thankful to the Operational Programme Education for Competitiveness co-funded by the European Social Fund (ESF) and national budget of the Czech Republic for the grant No. CZ.1.07/2.3.00/20.0147 - “Human Resources Development in the field of Measurement and Management of Companies, Clusters and Regions Performance”, which provided financial support for this research.

M. Kubíčková is with the Tomas Bata University in Zlín, Faculty of Management and Economics, Department of Management and Marketing, Mostní 5139, 760 01 Zlín, Czech Republic, phone: 00420 57 603 2861, e-mail: m1kubickova@fame.utb.cz.

L. Smékalová is with the Tomas Bata University in Zlín, Faculty of Management and Economics, Department of Regional Development, Public Sector Administration and Law, Mostní 5139, 760 01 Zlín, Czech Republic, e-mail: smekalova@fame.utb.cz.

at any stage of communication there is likelihood larger than zero that among communicating subjects a conflict will start stemming from misunderstanding in terms of different opinions, knowledge, or professed cultural values. Barriers to communication are identified and agreed upon by many authors (see [21], [18], [20], [7], and others). From the perspective of Porvazník's and Ladová's research the important factors seem to be knowledge, culture, status, attitudes, emotions and experience. This research will deal with several of the aforementioned barriers [18].

Barták expressed support for the idea that the unification of knowledge among the communicating subjects leads to much better communication clarity and assurance that the communication will be correctly interpreted. Knowledge represents an essential element of understanding and knowledgeable subject who has a greater degree of knowledge, should always adapt to communication with a weaker entity [1]. Another barrier in the communication is represented by the emotions. As defined above, communication is first and foremost a relationship. Every relationship establishes a certain emotional mood that subjects feel towards one another.

Attitudes of the separate entities on communication can significantly affect the willingness to communicate.

One of the most significant barriers constitute the cultural differences among subjects of management. German scientists Kroeber and Kluckhon has detected 164 various precise definitions of culture [16]. Reference [3] proposes that influence of the culture on individual is represented by a double-dependent relationship. Where there are the people on the one hand, co-authors of a certain type of culture and on the other hand, there is the same culture with its principles governing their behavior (see [5], [23]). Reference [22] describes the importance of culture for communication in an international environment. It confirms the idea that in this area culture is viewed as an key factor [see 10].

Most of the individuals are monocultural. It means these individuals live all their life in one cultural environment and maintain one cultural framework for determining their values and attitudes. Each member of a culture interprets the behavior of other members regarding to their own set of cultural values. The behavior of members of certain cultures who have to interact and cooperate with individual representing different cultures may be sometimes difficult, impossible even. This fact represents a latent danger for communication [2].

Reference [19] established two hypotheses, which are essential elements in the relationship of culture and communication:

•„Each ethnic community, or each nation, has its own culture. In this sense, the concept of ethnic culture or national culture is used.

• One of the manifestations of human behavior is communication behavior. Therefore a close link between national culture and character of communication behavior exists".

According to these hypotheses the communication behavior constitutes the following figure that describes the connection of two elements-culture of the peoples and languages of nations.

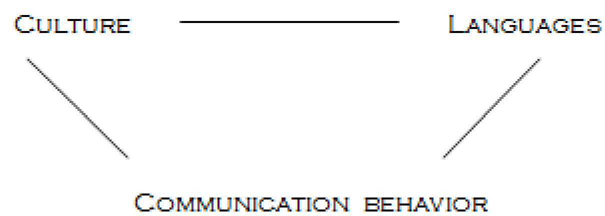


Fig. 1 Communication behavior. Source: [19]

III. THE ESSENTIAL FRAMEWORK OF DIFFERENCES BETWEEN EUROPEAN AND AFRICAN ASPECT OF CULTURE

When trying to understand a different culture people usually encounter their own cultural preoccupation. This is essentially a tendency to a more critical view of other unknown cultures and perspective to its members as objects of analysis [21].

The Europeans encounter the limitations of their own culture when they try to deal with African culture. Europeans are not allowed to see the African culture other way than through the lens of their own culture. They perceive it as a less valuable within European standard views on independence, individualism and freedom compared to the values of African culture based primarily on depending on individual members, collectivism and compliance with mandatory standards of social hierarchy. The Europeans do not understand these values in the same context as the members of the African culture.

The following figure shows the relationship of European culture and the African based on model of Ishiio and Satoshi who proposed a three level structure model. The first level represents mental layer (life values, beliefs and attitudes). This layer is the most hidden and least discoverable. The second layer constitutes a behavioral sphere (based on verbal and nonverbal behavior) and the third is the material layer (which is represented by plenty of indicators such as clothing, food, etc.) [25].

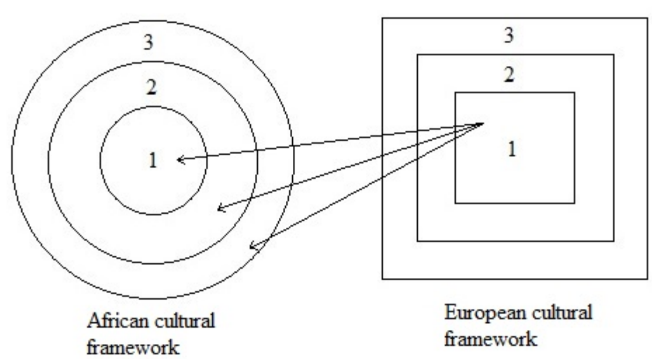


Fig. 2 Ishiio Santoshi cultural relationship model. Source: [25]

IV. Methods and Data

This research targeted middle-ranking Czech managers who provided the data on Czech communication specifics and their communication techniques as well as the African employees of significant Algerian origin proportion. Data were complemented by secondary data of the previous research of the authors and considered the Hofstede dimensions. The survey was also discussed and response accuracy was encouraged the accuracy of responding by interpretation problems reduction.

An African part of research was based on a total of 250 questionnaires which were distributed among employees of state and private companies. 162 questionnaires of three countries of Africa (Algeria, Niger and Ghana) were received and useable for the purposes of data analysis. The questionnaire the respondents answered on consisted of the 5-point Likert style statements.

The Czech part of research was conducted with the cooperation of middle- ranking Czech managers. It was partly covered by personal semi-structured interview and partly by a questionnaire. The main results covered the topic of communication of either multicultural teams lead by Czech managers or multicultural teams where Czechs were involved as employees. Resulting recommendations for the Czech managers included an effort to use only mild authority in order to encourage the employees to communicate more freely with their superiors, however, in such a case the final control of employees' work must be rather thorough. Both Czech managers and employees prefer English as a means of communication with foreign colleagues with distinct correlation to the age group. The younger the person was the more willing he was to communicate in English [13].

Based on the theoretical background of the researches two basic hypotheses were established:

H1: The proportion of employees who are not accustomed to open communication with their superiors regarding their new ideas and innovations is higher than 50%.

H2: There is a relationship between age and communication barriers of employees which the employees face in their current job.

The hypotheses were tested using the descriptive statistics and associations between the variables. The Grounded theory was elected for qualitative data and objective is the specification of the conditions under which the phenomenon of communication occurs. The descriptive statistic was used to verify the normal distribution in variables. Hypothesis H1 was tested by proportions test with continuity correction. The proportion of those who are accustomed to openly communicate with their superiors regarding their new ideas and innovations was 74.69 % in this sample. It is possible to claim that the proportion of those who are accustomed to openly communicate their new ideas and innovations towards the superiors is higher than 50 %. Hypothesis H2 was tested by Fisher's exact test and Chi- squared test with Monte Carlo simulation due to failure to meet the conditions for Person's Chi- squared test. However, this test did not establish that there was a relationship between age and preferred communication method but it demonstrated that there is a relationship between age and language that can act as part of the cultural barriers. The confidence level was set on 5 %. To link the findings regarding the African people and the Czech staff the authors' secondary data have served. These data deal with the research of Czech workers and managers communication specifics.

V. Set of Principles for Effective Communication between the Groups of Czech Managers and African Employees

African employees (Algerian more than others) are willing to share their new ideas and innovations ordered quite openly. Therefore, this can be used for regular meetings and listen to their opinions, and especially in this actively promote a reassuring on accuracy.

Educated employees communicate their ideas more easily. The willingness to share their ideas and innovations plays a role in employee training. Therefore, the more proactive and supporting supervisors achieve better results. The manager must also focus on the fact that better educated workers communicate their thoughts easily but this openness and enthusiasm are decreasing with lower education.

The age of employees does not significantly affect the perception of various communication barriers. However, employees aged 27 to 40 years are less susceptible to perceive emotions as barriers to communication. Anyway the research shown it is suitable to apply only a moderate degree of authority. This area represents very sensitive point as it is very different from the expectations of managers accustomed to working habits of Czech employees. Employees themselves assess emotions, except the group aged between 27 and 40 years of age, as the most significant barrier. It is essential that the manager insists on observing the fundamental regulations of the company and the employees know what is necessary to execute and thereby prevent rather emotional reactions of staff when the task cannot be executed. Generally can we can anticipate a certain degree of unreliability which can be partially eliminated by positive motivation or material motivation.

Generally speaking, the younger are employees, the easier they find the possibility to communicate in English across all countries surveyed. The employees aged 18 to 26 years are an age group that communicates in English most easily. A significant proportion of employees prefer the French language in the case of the Algerian employees. The proportion of

French speaking employees is present in all age groups, except the employees aged 18 to 26 years in such significant numbers that it is appropriate to recommend the knowledge of this particular language as an important advantage.

The recommendations focus on the diversity of cultures and their importance for the ability to communicate. Individual rules are drawn up in the form of commented recommendations and their key idea is to eliminate barriers of communication as much as possible. In general, this paper deals with identifying individual areas which are different for two sided communication and could constitute problematical friction surfaces. Recommendations are devoted to the willingness of employees to communicate new ideas, improvements and innovations. This area is imperative for the proper development and continued existence of the company in a competitive environment. It is important to involve in the operations those employees who have the greatest knowledge of their work and in addition work in familiar environment. This paper deals also with the influence of the age on the perception of communication barriers with special emphasis on the degree of influence of perceived cultural barriers and age.

VI. Conclusion

The recommendations focus on the diversity of cultures and their importance for the ability to communicate. Individual rules are drawn up in the form of commented recommendations and their key idea is to eliminate barriers of communication as much as possible. In general, this paper deals with identifying individual areas which are different for two sided communication and could constitute problematical friction surfaces. Recommendations are devoted to the willingness of employees to communicate new ideas, improvements and innovations. This area is imperative for the proper development and continued existence of the company in a competitive environment. It is important to involve in the operations those employees who have the greatest knowledge of their work and in addition work in familiar environment. This paper deals also with the influence of the age on the perception of communication barriers with special emphasis on the degree of influence of perceived cultural barriers and age.

Acknowledgment

The authors would like to thank Prof. Ján Porvazník for his support and methodological assistance.

References

[1] J. Barták, *Od znalostí k inovacím: tvorba, rozvíjení a využívání znalostí v organizacích*. Prague: Alfa, 2008.

[2] D. P. S. Bhawuk, “The role of culture theory in crosscultural training: A multimethod study of culture specific, culture general and culture theory-based assimilation,” *Journal of Cross-Cultural Psychology*, vol. 29, pp. 630-655, 1998.

[3] J. W. Berry, *Cross-cultural Psychology: Research and Applications*. Cambridge: Cambridge University Press, 2002.

[4] J. Dědina, and J. Odcházel, *Manaagement a moderní organizování firmy*. Prague: Grada Publishing, 2007.

[5] A. Durant, and I. Shephert, “Culture and communication in intercultural communiation,” *European Journal of English Studies*, vol. 13, pp. 147-162, 2009.

[6] J. Dvořáček, *Společné a nadnárodní podniky*. Prague: Oeconomica, 2006.

[7] P. Ferrago, *The Cultural Dimension of International Business*. Upper Saddle River: Prentice-Hall, 2002.

[8] M. B. Goodman, and P. B. Hirhch, *Corporate Communication*. New York: Library of Congress, 2010.

[9] M. Guirdham, *Communicating Across Cultures at Work*. Basingstoke: Palgrave, 2011.

[10] G. Hofstede, *Culture's Consequences: Comparing Values, Behaviors, Institutions and Organizations Across Nations*. Thousand Oak, CA: Sage Publications, 2001.

[11] S. Johnson, *Headquarters and Subsidiaries in Multinational Corporations*. Hampshire: Palgrave Macmillan, 2005.

[12] W. Krüger, *Vedení týmů*. Prague: Grada Publishing, 2004.

[13] M. Kubíčková. “Enhancement of Human Resource Practices of Multinational Corporations through Organizational Communication”. *In:* CD Innovation Vision 2020*: Sustainable growth, Entrepreneurship, Real Estate and Economic Development. Conference International Business Information Management Association* Barcelona, 2012, pp. 1551-1559.

[14] P. M. Lillis, and R. Tian, “Cross-cultural communication and emotional intelligence: Inferences from case studies of gender diverse groups,” *Marketing Intelligence & Planning*, vol. 27, pp. 428-438, 2009.

[15] R. Marschan-Piekkari, D. Welsch, and L Welch, “ In the shadow: the impact of language on structure, power and communication in the multinational,” *International Business Review*, vol. 8, pp. 421-440, 1999.

[16] P. Němec, *Integrovaná komunikace korporací*. Prague: VŠE, Fakulta podnikatelská, 2006.

[17] F. S. Nunez, and C. S. Simon, “Transfer of Knowledge in Multinational Corporations (MNC’s) on International Projects,” *Journal of Advanced Management Science*, vol. 2, pp. 228-231, 2014.

[18] J. Porvazník, and J. Ladová, *Celostní management*. Bratislava. IRIS, 2010.

[19] J. Průcha, *Interkulturní komunikace*. Prague: Grada Publishing, 2010.

[20] C. B. M. van Riel, *Principles of Corporate Communication*. Harlow: Academic Services and Prentice Hall, 1995.

[21] L. A. Samovar, R. E. Porter, and E. R. McDaniel, *Intercultural Communication*. Boston: Wadsworth, 2009.

[22] V. Soukup, *Přehled antropologických teorií kultury*. Prague: Portál, 2000.

[23] P. Spencer, *Culturally Speaking: Managing Rapport Through Talk Across Cultures*. London: ECE, 2000.

[24] Š. Vymětal, *Krizová komunikace a komunikace rizika*. Praha: Grada Publishing, 2009.

[25] J. T. Warren, and D. L. Fasset, *Communication-A Critical/Cultural Introduction*. Thousand Oaks: Sage Publishing, 2011.

The Short-term Power Consumption Forecast Based on the Forecasting of Decomposed Load Model Factors

Evgeny A. Plesnyaev, Pavel A. Kuzin, Anton A. Suvorov

***Abstract*—** A new decomposed method for electrical power consumption forecasting is under consideration. The proposed method is taken to be the opportunity to improve the accuracy of load forecasting and power generation planning. Test calculation results are presented. Further research directions are proposed.

***Keywords*—** Energy consumption, power system planning, power system analysis computing, power generation dispatch.

I. Introduction

The power consumption forecast is the very important component of technological power system state control and a power market dispatch. Load forecasting quality (accuracy) is of great importance for some technical and economic problem solving (e. g. generating equipment configuration scheduling, pricing at competitive electrical power market and so on). At the same time the complexity of exact forecasting problem is closely coupled with random load variations which are either time-varying function or some other internal and external random factors dependent.

The major parameter in term of load forecasting is forecasting interval. According to the magnitude of forecasting interval one has the opportunity to outline three forecast groups: run-time forecast (from several minutes to several hours forward); short-term forecast (from several hours to several days forward); long-term forecast (months or years forward).

There are many application of forecast technique in the power industry. The results of power forecasting are used while solving a wide range of problems rose during the processes of operation, control and maintenance of power system: for example, power generation dispatch [1], energy management system (EMS) [2],[3], electrical equipment assessment [4],[5],[6] and so on. According to the purpose of forecasting run-time, short-term, or long-term problem should be solved. This paper deals with short-term forecasting.

This work was supported by the Ural Federal University, Yekaterinburg, Russian Federation

E. A. Plesnyaev is with the Ural Federal University, Yekaterinburg, Russian Federation (phone: +7(912) 200-8383; fax: +7(343) 359-1516; e-mail: plesniaev@urfu.ru).

P. A. Kuzin is with the Ural Federal University, Yekaterinburg, Russian Federation (phone: +7(343) 375-9577; fax: +7(343) 359-1516; e-mail: p.a.kuzin@urfu.ru).

A. A. Suvorov is with the Ural Federal University, Yekaterinburg, Russian Federation (phone: +7(343) 375-9577; fax: +7(343) 359-1516; e-mail: suvorov.s.a@urfu.ru).

II. Short-term Forecasting

The forecasting techniques which are currently used could be divided into following groups:

- One-dimensional models (multiplex autoregressive models, linear and non-linear dynamical models);
- Cause-effect models (regression models, load decomposing models);
- Artificial intelligence techniques (expert systems, fuzzy logic models, artificial neural networks).

The detailed review of the forecasting techniques is presented in [7]. The short-term forecasting models under consideration are involved in [8],[9].

The results of the analysis of separate model factors approximation which was made by authors are brought in [10]. It appears to be useful to show the consequence of the approach steps.

Time series of power measurements was approximated by Fourier polynomials at day intervals. Every day interval (day load profile) provided the set of model factors which has their own time series with 1 day cycle. By-turn, the obtained model factor time series was being approximated by simple models (two or third degree polynomial). So the calculated time dependency was used to find the model factors and then original model was being determined. It gave the opportunity to assess the day load profile.

The research has brought out that this approach enables to determine the original load profile at any point of the time interval under consideration. So one could suppose that it is available to use such approach for load forecasting.

In terms of the problem under consideration the physical process model was named “basic model” and the models of the basic model factors were named “additional models”. In this manner it makes it possible:

- To use more simple models for factors;
- To use the individual models for each factor.

It is only natural that it makes this approach more flexible.

ISBN: 978-1-61804-255-2

In another way the essence of the method is forecasting of factors of the model which simulates the behavior of forecasting parameters.

The calculation series were made to test the proposed method. The test calculations were based on power consumption and temperature measurements for all power utilities of the Ural Power System (Russia).

To begin with, it was supposed that basic model could include any parameters which are provided with reliable data (actual and prognostic) while the additional models have to be built as time functions. However it appears that it is appropriate to include external parameters (e.g. temperature) into the additional models. Basic models for all experiments were based on day quantities of model factors. It is important to note that one has to obtain the day equivalent of the external parameter to include it into the model. So far as temperature was concerned it was necessary to average its measurements at day interval. An actual load profile dependence on the day of the week was also taken into account. Besides it was kept in mind that load profiles are similar for the same days of the week. That is why the basic model factors for respective days were used for making-up of retrospective intervals for additional models. In this experiment the holydays were excluded.

The temperature measurements were preprocessed. The preparation procedure consisted of smoothing and time shifting to make it possible to take into consideration load reaction delay. The time shift magnitude was determined empirically by analysis of correlation function of power consumption and temperature.

I. Test Calculation Results

The time interval was conditioned by one of applications of considered technique – generating equipment configuration scheduling. It was varied with quantities presented in Table 1. This table also contains retrospective interval values which are assigned empirically.

Basic model was composed of two elements assigning load dependence on time and temperature. As it was referred time dependence was simulated by Fourier polynomial. It consisted of 10 harmonic components for described experiment (the number of harmonic components was determined by irregular component level dependence on the terms of series number). Temperature function was designated by more simple models (power functions under third degree). The Table 2 contains variants of basic model configuration. The additional model configuration variants are presented in the Table 3.

The configurations listed in the Tables 1–3 give 96 different variants. Every considered variant included forecast calculating for determined time interval separately for every day of the week on the base of data for nine regions of the Ural Power System. Certainly the model configurations presented are not definitive. They are only illustrating possible variations. The similar calculations conducted continuously with new data acquisition.

TABLE I
SAMPLE PARAMETERS

Variant	Forecasting interval, number of data points	Retrospective interval, number of data points
1	1	8
2	1	4

TABLEII
BASIC MODEL CONFIGURATION

Variant	Independent parameter	
	«Time» (number of measurement)	«Temperature»
1	Fourier polynomial	not allowed
2	Fourier polynomial	linear model
3	Fourier polynomial	quadratic expression
4	Fourier polynomial	cubic expression

TABLE III
ADDITIONAL MODEL CONFIGURATION

Variant	Independent parameter	
	«Time» (number of measurement)	«Time» (number of measurement)
1	linear model	not allowed
2	linear model	linear model
3	linear model	quadratic expression
4	linear model	cubic expression
5	quadratic expression	not allowed
6	quadratic expression	linear model
7	quadratic expression	quadratic expression
8	quadratic expression	cubic expression
9	cubic expression	not allowed
10	cubic expression	linear model
11	cubic expression	quadratic expression
12	cubic expression	cubic expression

The method used to determine base and additional model factors are considered in [10].

The statistical characteristics such as average absolute error, average relative error, arithmetic mean value of an error, distribution median, forecast average squared error [12] was evaluated by forecasting results.

It appears sufficient to use average relative error (maximum permissible value was established) and forecast average squared error to estimate an accuracy of the forecasting. Conclusion was made by the results of comparison of errors and irregular component level for considered area.

Results of approximation of time dependences of factors of model are presented in Fig. 1. In Fig. 2 load profiles for one of days of a range of the used data are resulted: the actual; received on initial model; received on model with "the restored" factors. In other cases similar results have been received.

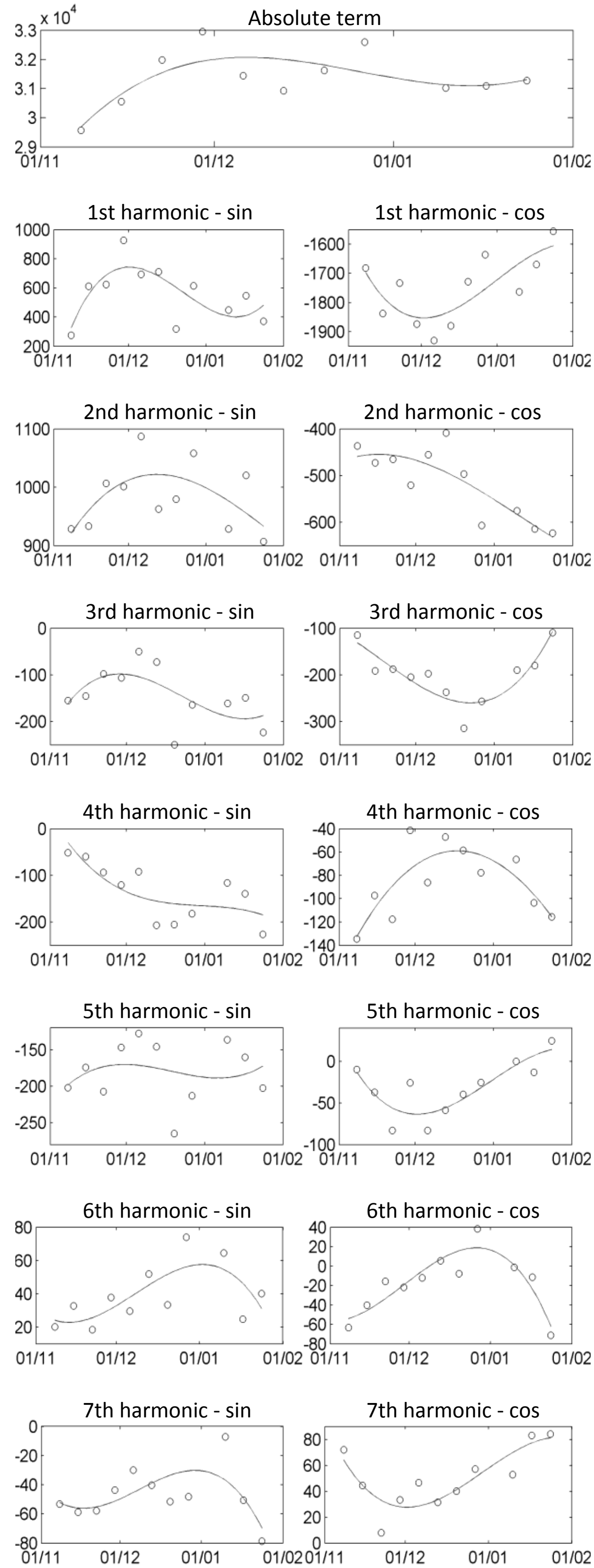


Fig. 1. Model factors approximation

Influence of environmental conditions, including air temperatures, on power consumption is well-known and widely enough shined in the literature. Certainly, it should affect and results of the spent experiment.

Experiments for research of ways of the account of influence of climatic parametres are at present planned for power consumption to carrying out. One has the reasons to believe that after allocation of influence of climatic factors, more stable results can be received.

In both cases the base model represents a polynom of Fourier from 10 harmonic components (Table II, variant 1). Additional models in the first example (Fig. 2) are set by a combination of linear time dependence and temperature dependence(Table III, variant 2). In the second example (Fig. 3) all additional models are a combination of linear dependences on number of measurement and quadratic expression from temperature (Table III, variant 3). In Fig. 4 histograms of distribution of deviations of look-ahead values of loading from the actual are resulted.

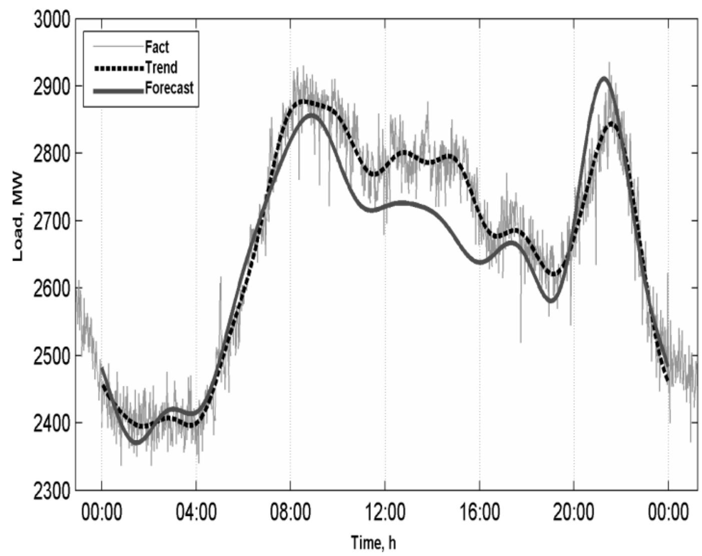


Fig. 2. Forecasting results (example 1)

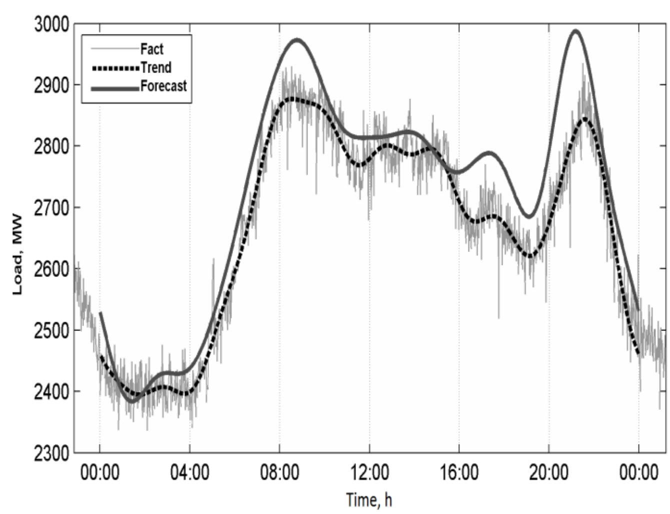


Fig. 3. Forecasting results (example 2)

It is necessary to notice that at experiment carrying out the data about a current power consumption, corresponding to the period of instability of temperatures was forcedly used, observed practically in all territory of Russia in the winter 2006-2007 air Temperature underwent considerable changes on short intervals of time, was fixed is abnormal warm weather for winter time.

Values of an average relative error and average quadratic forecast errors are equal accordingly: 1,72 % and 58,6 MW in the first example and 2,28 % and 75,7 MW in the second example. The size of an average quadratic deviation of the irregular component, received by results of approximation of a daily production schedule has made 31,6 MW. In all considered variants average relative errors of the forecast do not exceed 3 %. Errors of such level keep within admissible borders that speaks about possibility of application of the given method for forecasting.

The further researches will be directed on selection of more exact mathematical models, and also on search of methods of adaptive adjustment of models depending on change of character of the initial data.

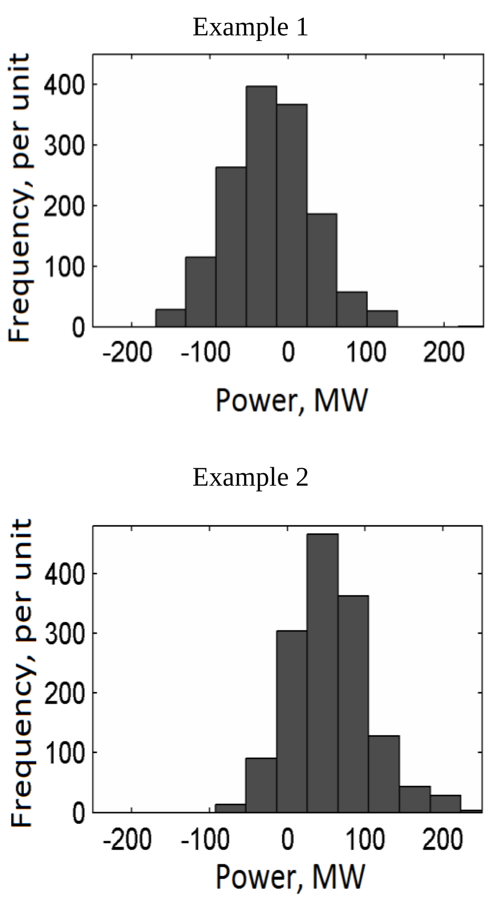


Fig. 4. Error distribution

II. Conclusion

By results of the calculation experiment it is possible to draw following conclusions:

- The form of load profiles is restored with enough fine precision;
- It is enogh to know value of daily power consumption to restore the load profile.
- It is established that cases in which authentic approximation of model factors change of has appeared inconvenient, correspond to the least significant factors of elements of initial model

References

[1] U. Navon, I. Zur, D. Weiner. "Simulation model for optimising energy allocation to hydro-electric and thermal plants in a mixed thermal/hydro-electric power system". Generation, Transmission and Distribution, IEE Proceedings, vol. 135, Issue: 3, 1988, pp 182 – 188.

[2] M. J. Huggins, M. S. Mirsky. "Optimal Energy Transactions in Interconnected Electric Systems". Power Apparatus and Systems, IEEE Transactions on, vol. PAS-104 , no. 11, 1985, pp 2994 - 3003

[3] Le Xie ; Ilić, M.D. "Model predictive economic/environmental dispatch of power systems with intermittent resources", Power & Energy Society General Meeting, 2009. PES '09. IEEE, 2009, pp 1 - 6

[4] S. A. Dmitriev, S. E. Kokin, A. I. Khalyasmaa. "Assessment of State of Urban Power Supply Systems' Power Transmission Lines On the Basis of Indicative Analysis". Applied Mechanics and Materials Vols. 291-294 (2013) pp 2143-2148.

[5] S. A. Dmitriev, S. E. Kokin, A. I. Khalyasmaa. "Assessment of Power Transformers Technical State Based on Technical Diagnostics". Applied Mechanics and Materials Vol. 492 (2014) pp 218-222

[6] S. A. Dmitriev, A. I. Khalyasmaa. "Power Equipment Technical State Assessment Principles". Applied Mechanics and Materials Vol. 492 (2014) pp 531-535.

[7] Hippert H.S., Pedreira C.E., Souza R.C. "Neural networks for short-term load forecasting: a review and evaluation", Power Systems, IEEE Transactions on, Vol. 16, No. 1, Feb 2001, pp 44 - 55.

[8] I. Moghram, S. Rahman, "Analysis and Evaluation of Five Short-Term Load Forecasting Techniques". Power Engineering Review, IEEE. vol. 9, No 11, 1989 , pp 42 – 43.

[9] S. Rahman, R. Bhatnagar. "An expert system based algorithm for short term load forecast". Power Systems, IEEE Transactions on, vol. 3, no. 2, 1988, pp 392 – 399.

[10] A.S. Berdin, P.A. Kruchkov. "Determining of power system model parameters for state control". Yekaterinburg: USTU–UPI, 2000

[11] P.A. Kuzin, S.A. Suvorov. "Forecasting Models Behavior Research". Proc. XIII International conf. of young scientists. Tomsk, Russia, 2007, pp. 57-59.

[12] M. Melnik. "Applied Statistics Fundamentals". Moscow: EnergoAtomIzdat, 1983.

New developed Visual Basic application in off-line transformer oil monitoring

Sonia Degeratu, Laurentiu Alboteanu, Sabin Rizescu, Daniela Coman, Aida Bulucea

***Abstract*—**This paper presents a Visual Basic Application, called "LABVIB" by authors, which was developed for monitoring transformer oil condition. This application offers possibilities of rapid storage, visualization and analysis of data resulting from periodical check-out of parameters considered as being relevant to describe the state of oil in power transformers. The paper also includes the experimental results obtained by measuring the state parameters of electro-insulating oil for the each stage of monitoring: breakdown voltage, loss angle tangent, acidity index, water contents, number of particles larger than 5 microns, interfacial tension, and gas contents.

***Keywords*—**Transformer mineral oil, LABVIB application, off-line transformer oil monitoring, state parameters, gas contents.

I. Introduction

Most companies tend to use electricity at the optimum and at a high coefficient of safety of their existing equipment. A use of this kind, in association with assimilating new technologies, is always actual and constantly rising. To reduce the risk of damage in a power transformer, which is the most expensive equipment in any power system, it turns necessary to perform continuous monitoring while it is operating, by acquiring and processing detailed information about the status of the transformer. This way, any eventual transformer damage can be prevented [1-3].

Almost any power transformer is filled with mineral oils because a mineral oil holds insulating, cooling and oxidation stability properties [3].

Transformer oil deteriorates because of electrical, thermal, mechanical and climatic stresses which do occur while any power transformer does operate [1], [4-7]. Oxidation products as well as whatever other undesirable contaminants, such as water, solid particles, in-oil-soluble polar compounds that accumulate in the oil, while operating, may affect transformer electrical properties.

Liam Warren from ABB once made a famous statement [8]: "The oil contains around 70% of the available diagnostic information for the transformer".

As a conclusion, monitoring in real-time the state of a power transformer turns to be of great importance in ensuring its reliability and security [2], [9].

In the same kind of respect, Tim Cargol, stated [9] "Experience has shown that most internal transformer condition problems can be detected through oil analysis". To check on the oil quality, the oil is tested on regular basis and each result coming from all testing procedures will be compared with its regulated value [10-12].

Continuous monitoring (off-line or on-line) of oil quality is a really good diagnostic method because it provides information on how transformer is being managed and how long it might be expected to operate before any oil regeneration/replacement might be required or any major service might occur. This continuous monitoring turns to be very useful in anticipating any severe fault, and enables the user to take appropriate action to before it will actually occur.

The aim of this paper is to present the results of in-the-laboratory-performed experiments (off-line) on samples of non-additive TO 30.01 mineral oil, during three years of monitoring period that consisted in five stages. This oil comes from a power transformer (63MVA, 110kV/10, 5kV, 330A) working in the Romanian power network.

For quick analysis and interpretation of all obtained experimental results, the authors have developed a Visual Basic application which they called LABVIB. The paper presents the existing advantages of the application and how it effectively works.

II. Monitored Parameters Selection

Off-line monitoring of non-additive mineral oil contamination was done by verification on regular basis of representative oil parameters. This verification, consisting in five stages, was done on oil samples collected from the operating transformer (63MVA, 110kV/10, 5kV, 330A) every six months for three years. This monitoring activity started in 2009, two and a half years after Functioning Reinstatement of

This work was partially supported by the grants numbers 7C/2014 and 29C/2014, awarded in the internal grants competition of the University of Craiova.

S. Degeratu is with University of Craiova, Faculty of Electrical Engineering, Department of Electromechanics, Environment and Industrial Informatics, 200440 Craiova, Romania (corresponding author to provide phone/fax: 040-251-435255; e-mail: sdegeratu@em.ucv.ro).

I. L. Alboteanu is with the University of Craiova, Faculty of Electrical Engineering, Department of Electromechanics, Environment and Industrial Informatics, 200440 Craiova, Romania (e-mail: lalboteanu@em.ucv.ro).

S. Rizescu is with the University of Craiova, Faculty of Mechanical Engineering, 200440 Craiova, Romania (e-mail: sabin_rizescu@yahoo.com).;

D. Coman is with the University of Craiova, Faculty of Mechanical Engineering, Romania, 200440 Craiova (e-mail: amdcoman@yahoo.com).

A. Bulucea is with the University of Craiova, Faculty of Electrical Engineering, Department of Electromechanics, Environment and Industrial Informatics, 200440 Craiova, Romania (e-mail: abulucea@em.ucv.ro).

the Transformer, which was performed after it was repaired and after the oil was replaced.

The non-additive mineral oil type TO 30.01 used to fill the transformer in question was purchased from the MOL Hungary.

The purpose of this monitoring activity was real-time notification of any change in oil state, preventing this way any significant risk of damage, considering that the transformer whose oil is under investigation works for more than 28 years.

A large number of tests can be applied to oil taken from the transformer in service. Testing the following representative state parameters is considered to be sufficient to determine whether the condition is suitable for oil to continue to operate and to suggest the necessary corrective action to be taken [1], [8], [9], [13-17]: breakdown voltage, loss factor, water contents, acidity index, interfacial tension, number of particles larger than 5 microns and gas contents or dissolved gas.

The measurements of these representative state parameters of tested oil were done using the following equipments and according to the following norms:

- MEGGER- LIMITED Dover Kent England, used for measuring the breakdown voltage according to IEC 60156 [18];
- BAUR DTLC Dielectric Strength Tester, used for measuring the dielectric dissipation factor according to IEC 60247 [19];
- CA-21 Coulometric Karl Fischer Moisture Meter - Mitsubishi, used to determine the water contents according to IEC 60814 [20];
- Biurette Digital TITRETTE - BRAND Germany, used to determine the acidity index according to IEC 62021 [21];
- Sigma 702ET Tensiometer – Finland KSV Instruments, used to determine the interfacial tension according to STAS 9654 [22];
- Portable Particle Counting System for Oil, type PAMAS–S40, used to determine the number of particles larger than 5 microns according to IEC 60970 [23];
- Gas Chromatograph CLARUS 600 - Perkin Elmer Instruments, used to determine the gas contents according to IEC 60567 [24].

Oil samples for these tests were taken from the transformer in service according to the following standards: IEC 60567 [24] for gas contents test and SR EN ISO 3170 [25] for all other tests.

III. LABVIB APPLICATION AND HOW IT WORKS

LABVIB is an application which runs under Visual Basic environment. The destination of developing this LABVIB application does consist in monitoring the state parameter values that were determined during each of the five monitoring stages. Because data acquisition is made off-line, the user has to bring into application the measured value of each parameter.

The implemented Visual Basic project allows quick storage, visualization and a stage by stage kind of analysis of experimental results and interpretation of all obtained results as a whole, after all monitoring stages were performed.

When the LABVIB application starts to run, a user main dialog interface window is displayed, Figure 1. It contains dialog boxes and command buttons for opening new windows.

This window entitled "Transformer oil monitoring" contains:

- boxes at the top left of the window, where initial data are brought. These data are concerning: the station from which the transformer (the one from which the oil was taken) belongs to and data concerning the oil type and the transformer;
- boxes at the bottom-left of the window, where the monitored parameters are brought;
- boxes at the bottom-right of the window, where are to be brought: the monitoring stage, its corresponding year and if the stage was performed or it is to be performed;
- control buttons placed at the bottom-right of the window, for each monitoring stage and for its overall results displaying.

For example, pressing "Stage 1" button in the main window, leads to the opening of the dialogue sub-window that characterizes this stage (Figure 2).

In the boxes at the top-left of this sub-window, the user will bring data concerning the time date and place of taking the oil sample. In cells belonging to the middle part of the window, the user will bring the parameter values obtained from measurements performed at stage 1. Also in this area, the user will bring the recommended values and the reference values of oil state parameters, respectively. If just one of the measured values exceeds its recommended value, the box will take the blue color, and by activating it, the red color.

At the bottom of the sub-window of Figure 2 there are boxes where the user will bring the measured values, the recommended and the reference values for concentrations of in-oil-dissolved gas and for CO_2 / CO ratio, corresponding to this stage. If just one of the measured values exceeds its recommended value, the box will take the blue color, and by activating it, the red color (see, in Figure 2, the box corresponding to the determined value of CO_2 / CO ratio).

Also in this sub-window, the user will find the button placed at the top-right which is entitled "Graph displaying". By pressing this button, graphics containing the relative values of state parameters and of dissolved gas concentrations as well, will appear (Figure 3).

The recommended values of the state parameters and of dissolved gas concentrations are those given by literature [1, 5]. Any relative value was calculated as the ratio between the corresponding measured value and the reference value of the considered parameter.

As reference value for each and every oil state parameter, except the interfacial tension value, the corresponding value measured during commissioning, was considered. Since there was no interfacial tension value during the commissioning, the measured value during the first stage of monitoring was considered as reference value.

For dissolved gas content, the value recommended by literature [1, 5] was considered as reference value and that because we have not any commissioning value for this parameter.

Pressing the "General results displaying" button in the main window (Figure 1) leads to the appearance of graphs that contain experimentally determined results for all performed stages (Figure 4).

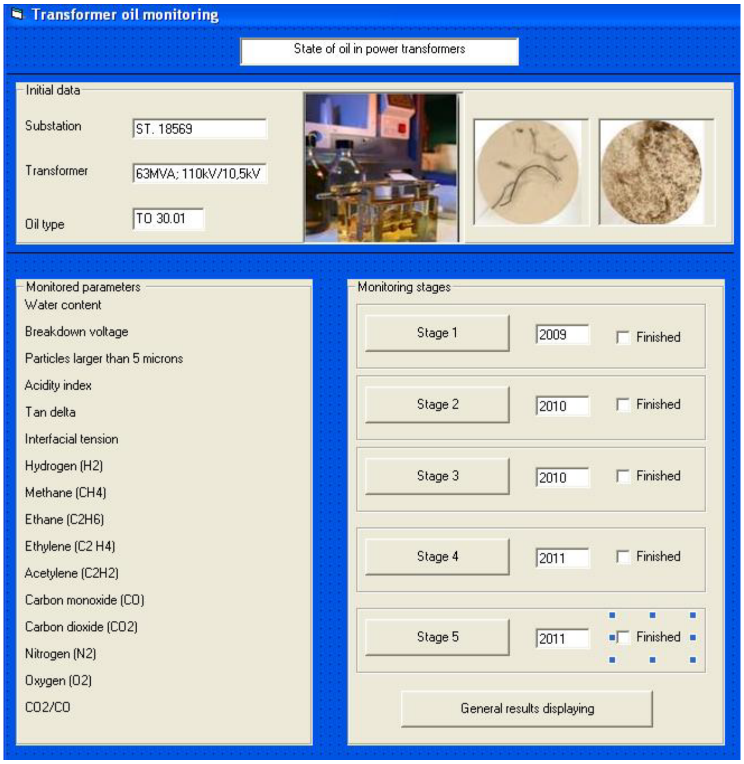


Fig. 1. Dialog main interface called ”Transformer oil monitoring”

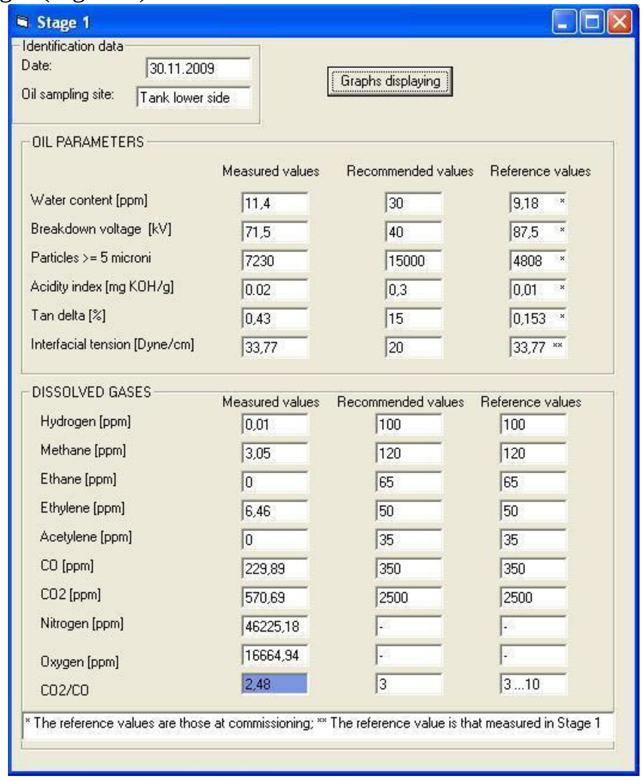


Fig. 2. Dialog interface sub-window called ”Stage 1”

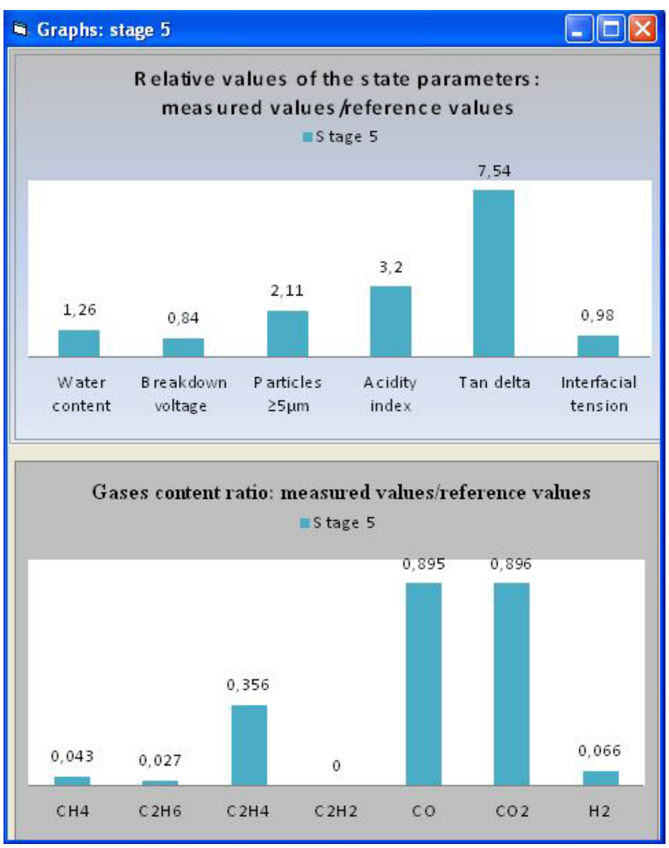


Fig. 3. Graphs containing the relative values of state parameters and of dissolved gas content corresponding to stage 1

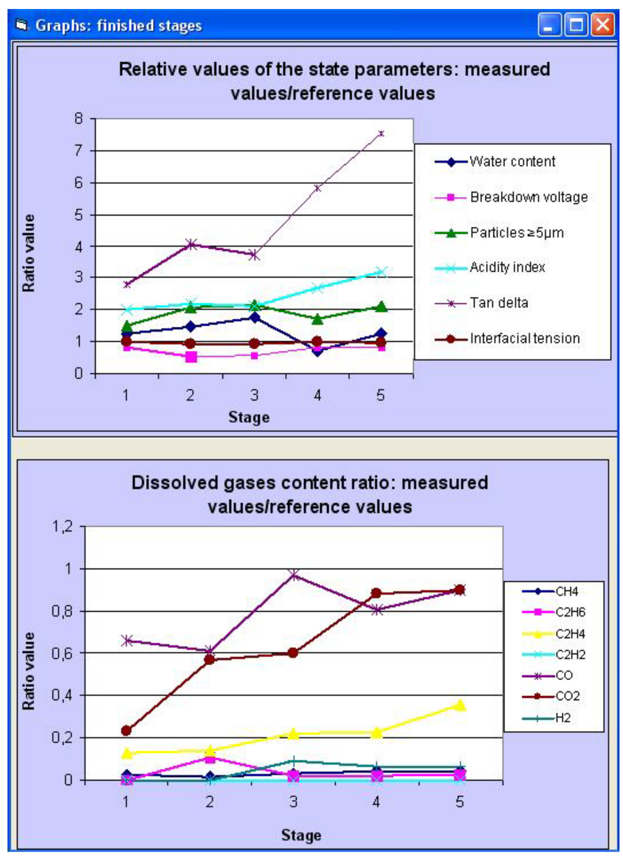


Fig. 4. Graphs containing overall results for all monitoring stages

Analyzing this figure, it becomes easy to observe the time evolution of state parameters relative values and of dissolved gas content, for all monitoring stages.

This LABVIB application has the following advantages:

- has a friendly and intuitive interface, allowing use without requiring any user expertise;
- presents appropriate dialog boxes for quick and easy configuration of analyzed parameters;
- enables quick display of measured values for all monitored parameters, during each monitoring stage;
- warns when just even one of the measured parameters does not fit within the recommended values;
- presents remarkable facilities to analyze the results, concerning each monitoring stage as well as all performed monitoring stages;
- makes possible data storage and building, this way, an oil behavior background, during a certain monitoring time.

IV. Discussion

Analysis results across the entire monitoring period of oil (Figure 4) concerning determination of electrical, physical and chemical properties of oil led the authors to conclude:

- measured values of all state parameters are within the limits recommended by the existing regulations and literature;
- there is a correlation between the values obtained for the parameters whose behavior has described similar states of oil;
- at the stage 1, the determined value of CO_2/CO ratio does not fit within limits recommended by the existing regulations and literature. Because this ratio meets the regulation criteria at all the other stages (2, 3, 4 and 5) we argue that the unfit of the stage 1 was accidental. The “de facto” situation corresponding to all stages except stage 1 leads to the conclusion that there is no paper involved in inducing a defect with a significant degree of carbonization due to insulation overheating.

V. Conclusion

The transformer insulating oil could provide really valuable information on the condition of the transformer. These oil related data make it possible to anticipate any potential failure in the transformer, achieving this way a proper maintenance and a good planning to recondition or replace the oil.

The paper presents the results of experiments made on samples of TO 30.01 mineral oil that were taken over three years of monitoring, in five stages, starting in 2009. All samples came from a power transformer still working in the Romanian power network after a little bit more than 28 years in service.

A LABVIB application is designed to monitoring the obtained results and interpreting them. This application offers the following opportunities: proper setup dialog boxes for quick and easy configuration of analyzed parameters, outstanding facilities for analyzing the results obtained and the possibility of quick display of measured values and warning if just even one limit value is exceeded.

The values obtained for oil parameters show that they meet all requirements imposed by existing rules in this area and there are only small chances for the transformer to be affected by any predictable fault while it operates.

By using a complex evaluation of all obtained results, the authors are in a position to decide that the oil has not to be changed or reconditioned and the oil state fulfills all requirements needed for continued operation.

Acknowledgment

This work was partially supported by the grants numbers 7C/2014 and 29C/2014, awarded in the internal grants competition of the University of Craiova.

References

[1] M .M. EL-Sayed, R. S. Mohamed, and A. A. Wael, “Prediction of the characteristics of transformer oil under different operation conditions,” *World Academy of Science, Engineering and Technology*, vol. 53, pp. 764-768, 2005.

[2] H. Huimin, and X. Xiaotian, “Study on transformer oil dissolved gas online monitoring and fault diagnosis method,” *International Conference on Condition Monitoring and Diagnosis (CMD)*,. Bali, 2012, pp. 593–596.

[3] T. Gradnik, T. Gradnik-Koncan, N. Petric, and N. Muc, “Experimental evaluation of water content determination in transformer oil by moisture sensor,” *IEEE International Conference on Dielectric Liquids*, Trondheim, Norway, 2011, pp. 1-4.

[4] M. A. De Sousa Rios, and S. E. Mazzetto, “Effect of organophosphate antioxidant on the thermo-oxidative degradation of a mineral oil,” *J Therm Anal Calorim*, vol. 111, pp. 553-559, 2013.

[5] D. A. Batista, P. A. Patriarca, E. M. Trindade, and H. M. Wilhelm, “Colorimetric methodology for monitoring the cellulose insulating paper degradation in electrical equipments filled with mineral oil”, *Cellulose*, vol. 15, pp. 497-505, 2008.

[6] R. A. Lipshtein, and E. N. Shtern, “Effect of hydrocarbon composition of transformer oil on dielectric losses,” *Chem Tech Fuels Oil+*, vol. 3, pp. 363-366, 1967.

[7] A. A. Reykherdt, and V. Davydov, “Case Studies of Factors Influencing Frequency Response Analysis Measurements and Power Transformer Diagnostics,” *IEEE Electr Insul M*, vol. 27, pp. 22-30, 2011.

[8] L. Warren, “Transformers-Oil sampling–the comprehensive transformer health test,” 2010, http://www.electricalreview.co.uk/features/6760-118924.

[9] T. Cargol, “An Overview of online Oil Monitoring technologies,” *Fourth Annual Weidmann-Acti Technical Conference*, San Antonio, 2005, pp. 1-6.

[10] P. Shukla, Y. R. Sood, and R. K. Jaria, “Experimental Evaluation of Water Content In Transformer Oil,” *Int J Innov Res Sci Eng Technol*, vol. 2, pp. 284-291, 2013.

[11] *Mineral insulating oils in electrical equipment-Supervision and maintenance guidance, Multiple*, IEC TC10, IEC 60422 Ed. 3.0 b, 2005, Distributed through American National Standards Institute (ANSI), 2007.

[12] *IEEE Guide for Acceptance and Maintenance of Insulating Oil in Equipment*, IEEE Std C57.106-2006 (Revision of IEEE Std C57.106-2002), 2006.

[13] *Mineral oils technical exploitation regulatory statement*, PE 129, 1999.

[14] I. Felea, N. Coroiu, and I. Boja, “The influence of the stress level on electro isolating oil state from the electric power transformers,” *The 6th International Power Systems Conference*, Timişoara, 2005, pp. 223-230.

[15] Mohammad R. Meshkatoddini, „Aging Study and Lifetime Estimation of Transformer Mineral Oil,“ *J Eng Appl Sci*, vol. 1, pp. 384-388, 2008.

[16] S. M. Korobeynikov, Y. G. Soloveichik, A. L. Bychkov, D. V. Vagin, A. V. Melekhov, and A. Y. Ryzhkina, „Dissolution of diagnostic gas bubbles in transformer oil,” *High Temp+*, vol. 49, pp. 744-749, 2011.

[17] *Mineral oil-impregnated electrical equipment in service – Guide to the interpretation of dissolved and free gases analysis*, IEC 60599, 1999.

[18] *Insulating Liquids-Determination of the Breakdown Voltage at Power Frequency-Test Method*, IEC 60156, 2005.

[19] *Insulating liquids-Measurement of relative permittivity, dielectric dissipation factor (tanδ) and d.c. resistivity*, IEC 60247, 2004-2.

[20] *Insulating liquids-Oil-impregnated paper and pressboard–Determination of water by automatic coulometric*, Karl Fischer titration, IEC 60814, 1997.

[21] *Insulating liquids. Determination of acidity Part 1: Automatic potentiometric titration*, IEC 62021-1, 2003.

[22] *Mineral oils. Determination of interfacial tensions occurring on the interface between oil and water*, STAS 9654, 1974.

[23] *Insulating liquids–Methods for counting and sizing particles*, IEC 60970, 2007.

[24] *Oil-filled electrical equipment–Sampling of gases and of oil for analysis of free and dissolved gases-Guidances*, IEC 60567, 2005.

[25] *Oil and oil-based products. Sampling*, SR EN ISO 3170, 2002.

Analysis of Urban Comprehensive Carrying Capacity of the prefecture-level city in Gansu province

JING Li[12], MA Ling[3], CHEN Xingpeng[1]

***Abstract*—**Based on the theory of urban carrying capacity, this paper put forward twenty-two index applying to assess the problem of the prefecture-level city in Gansu province. The results show that resource carrying capacity become the most important factor that influenced the city development; the way of improving the urban comprehensive carrying capacity is the improvement of pressure-carrying index; the supply index does no tmatch demand index; the urban comprehensive carrying capacity presents stair-step decline; the leadership of two biggest cities are weaker relatively. To solve these problems, some measures are put forward such as changing the speed and mode l of development, improving the pattern of the human behaviors, et al.

***Keywords*—**urban carrying capacity, pressure-carrying index, supply index, demand index .

I. INTRODUCTION

CHINA'S urbanization has developed rapidly in the 21st century with an average annual rate of 3.1% growth and the urbanization rate reached 53.73% in 2013. The increasing scale of cities and the rapidly accumulating population have caused changes in the process of social and economic development. These changes not only represent an improving civilization, but also have brought great pressure to the urban resource, environment, transportation, and further affecting the further improvement of the quality of urbanization.

The word "capacity" first appeared in ecology, then gradually permeated into the environmental science, demography, economics. Now, it has become a concept which is closely related with resource endowment, technology, social choice and values with a relative limit connotation of ethical character [1].The concept of urban carrying capacity first appeared in 2002. K.O defined the concept of urban carrying capacity as as the material development of human activities, population growth and land utilization, which can realize the sustainable development of living environment system without causing degradation or irreversible damage [2].The concept was clearly put forward by the ministry of construction in January,2005,in "*the notification about strengthening the revision and approval of overall urban planning.*" .The study about urban comprehensive carrying capacity is relatively late. It mainly started after 2000, but it has produced certain achievements. Some scholars of have carried on quantitative analysis on the urban land resources, water resources, environment resources, mineral resources and other single factor of carrying capacity, and put forward the corresponding countermeasure [3] [4] [5] [6] [7].While, some scholars comprehensively evaluate the urban (land) carrying capacity from the perspective of multi-factors, construct evaluation index system, carry out empirical analysis and quantitative evaluation, and put forward the measures to improve the carrying capacity. [8] [9] [10].At the same time, some scholars expand the research scope to the comprehensive carrying capacity of urban agglomeration and have probed into the methods and ideas.The study mainly concentrates on the study of single urban carrying capacity factor and involves less comprehensive research that regards the city as a system..(3) the quantitative method has not formed a general calculation model, thus the evaluation results are diversified.(4) the study area is given priority to the southeast coastal developed areas, and the city carrying capacity related problems are rarely involved. To sum up, this paper argues that the urban comprehensive carrying capacity refers to the coordination and balance between population and human activities under certain resource constraints as well as the organic combination of human activity and natural resources, environment, economic and social conditions. At the same time, it should be realized that natural resource abundance and the city's economic development level do not have complete positive correlation and any social and economic development of a city is built on the basis of the synergy of many factors.[14].

As the pressure of the cities in the southeast coast continues to increase, western cities will become one important position of accepting transferring agricultural population, therefore the research of their comprehensive carrying capacity is especially important. This paper takes 12 district cities in the Gansu province as the research object, then establishes the index system of the urban comprehensive carrying capacity to conduct objective measurement and evaluation on the comprehensive carrying capacity of those 12 cities, with the purpose of analyzing the methods of improving the urban comprehensive carrying capacity and promoting the

1.College of Earth and Evironmental Sciences, Lanzhou University, Lanzhou 73000,

2.School of Urban Economics and Tourism culture, Lanzhou City University, Lanzhou 730070, Gansu China;

3.School of Education, Lanzhou City University, Lanzhou 730070, Gansu China

Corresponding author, e-mail: jinglilzu@163.com

coordinated development of the urban population, resources and environment.

II. Establish the Evaluation Index System of Urban Comprehensive Carrying Capacity

The data mainly comes from *the 2012 development yearbook of Gansu province*. The research object of this study is the 12 prefecture-level cities of Gansu province(Lin Xiazhou, Gan Nanzhou will not be evaluated due to the lack of data), including Lanzhou, Jiayuguan, Jinchang, Baiyin, Tianshui, Wuwei, Zhangye, Pingliang, Jiuquan, Qingyang, Dingxi, Longnan. Starting from the connotation of urban comprehensive carrying capacity and according to the regional characteristics, and the principles of being scientific, systematic, feasible, operational, the comprehensive carrying capacity index system of those 12prefecture level cities is established (figure 1), including target layer, base layer, criterion layer and index layer. Among them, the criterion layer includes two parts, the pressure index and pressure-carrying index.The pressure index refers to the demand pressures the city bears. Because the resources are limited and irrefragable, the greater the demand of the city for a certain resource, the more pressure the resource bears and the more limitation the urban development may face. Pressure carrying index refers to supply ability of the city. The more resources the city provides, the more development space the city has and the greater comprehensive carrying capacity the city has [15].

III. Modeling Method

A. The normalization of evaluation index

The data collected by evaluation index has different dimensions and units, thus needing to be standardized. Suppose that, X is the index for the urban comprehensive carrying capacity, corresponding to the sample matrix of city j and i evaluation index, namely the equation is $X = x_{ij}$.This paper divides the evaluation index into two major categories, namely the cost index and the efficiency index. The cost index refers to the indicators, the attribute value of which is negatively related to the urban comprehensive carrying capacity and the attribute value should be as small as possible. The efficiency index refers to the indicators, the attribute value of which is positively related to the urban comprehensive carrying capacity and the attribute value should be as big as possible [16].In order to eliminate the influence of the dimensions and dimensional units, this paper uses the fuzzy subjection function to nondimensionalize these two types of indicators..

The cost indicators use the glower semi-trapezoid fuzzy subjection function to nondimensionalize

$$x_{ij}^{'} = \begin{cases} 0 & x_{ij} = Mx_{ij} \\ \dfrac{Mx_{ij} - x_{ij}}{Mx_{ij} - mx_{ij}} & mx_{ij} < x_{ij} < Mx_{ij} \\ 1 & x_{ij} = mx_{ij} \end{cases} \quad (1)$$

The efficiency indicators use the glower semi-trapezoid fuzzy subjection function to nondimensionalize

$$x_{ij}^{'} = \begin{cases} 0 & x_{ij} = mx_{ij} \\ \dfrac{x_{ij} - mx_{ij}}{Mx_{ij} - mx_{ij}} & mx_{ij} < x_{ij} < Mx_{ij} \\ 1 & x_{ij} = Mx_{ij} \end{cases} \quad (2)$$

In the equation: $x_{ij}^{'}$ is the result of normalization and its value is between zero and one; x_{ij} is the original value of the index; mx_{ij} is the minimum value of the original values of different areas at the same period; Mx_{ij} is the maximum value of the original values of different areas at the same period

B. The determination of index weight

The entropy value method is a kind of objective weighting method. It can better avoid the deviation of the subjective assignment and determine the index weight according to the information provided by the original values of the indicators.And the indicators actually involved are expressed by the standardized value.The ultimate evaluation value and the level of the comprehensive carrying capacity is the product of both parts.The weight of the evaluation index system determined by the entropy method can fully reflect the description required by the level of urban comprehensive carrying capacity in the stress levels, pressure levels and coordination and the statistics also meet the requirements of entropy value method.Therefore, it is scientific to use the entropy method to evaluate comprehensive carrying capacity [17].Calculation steps are as follows:

1.Calculate the weight of index layer

First step:suppose that the index of the base layer(or criterion layer) is i, the index of the target layer is j, then the index weight p_{ij} of the Jth sample under the ith index is

$$p_{ij} = \frac{x_{ij}^{'}}{\sum_{i=1}^{n} x_{ij}^{'}}, n = 12$$

The second step:calculate the entropy e_j of the jth index:

$$e_j = -\frac{\sum_{j=1}^{n} p_{ij} \ln p_{ij}}{\ln p_{ij}}$$

The third step:calculate the utility value of the jth indicator: $g_j = 1 - e_j$

The fourth step:calculate the weight of the jth index:

$$w_j = \frac{g_j}{\sum_{j=1}^{n} g_j}$$

2.Calculate the weight of the criterion layer and the base layer

The evaluation system of the multilayer structure can, according to the additivity of the entropy, take advantage of the utility value of indexical information of lower to determine the weight value w_j corresponding to the upper structure value in proportion.In the previous steps, the utility value of each index has been calculated. Calculate sums of the utility value of each index of the lower structure, then get the utility value of all kinds of index,with the detonation $G_j,(j=1,2,\cdots)$. And subsequently obtain the sums of the utility value of all index: $G=\sum G_i$;the weight of the corresponding index: $w_i=\frac{G_i}{G}$

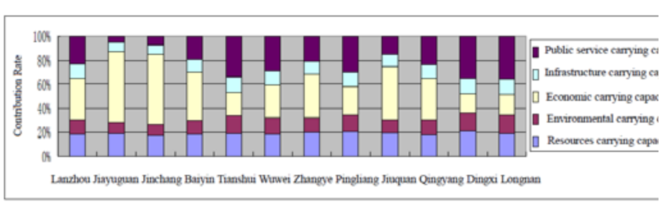
C. The construction of index model

For further research of the carrying capacity level used to evaluate the city, this paper adopts the urban comprehensive carrying capacity evaluation model. The comprehensive carrying capacity index systematically reflects the overall level of urban development ability under certain resources and environment constraints.At the same time we can also find out the short slab factors influencing the comprehensive carrying capacity, thus put ting forward the corresponding countermeasures.

The evaluation value of subsystem of the base layer adopts the following evaluation model: $Y_i=\sum_{i=1}^{m} w_j x_{ij}^{'}$ (3)

In equation: Y_i is the integrated assessment value of the ith subsystem in the base layer; m is the number of the evaluation index contained in the i th subsystem; w_j is the weight of the jth indicator in the ith subsystems; $x_{ij}^{'}$ is the evaluation value of the jth indicator in the ith subsystem.

The urban comprehensive carrying capacity value A of the base layer adopts the following evaluation model: $A=\sum_{i=1}^{n} w_i Y_i$. Obviously,the bigger A is, the better A is. Therefore, as the weight is known, we can easily determine every scheme or sort them according to the value of urban comprehensive carrying capacity.



Figuer.1 The rate of contribution of factors carrying capacity to urban comprehensive carrying capacity of the refecture-level city in Gansu Province

IV. The analysis of the comprehensive carrying capacity of the cities in Gansu province

A. The resources carrying capacity has the greatest impact on the comprehensive carrying capacity of the prefecture-level cities in Gansu province.

It can be seen from table 1 that among the weights of all subsystems which are determined by the entropy method, the carrying capacity of resources has the greatest influence,with a weight of 0.3075.The following are respectively economical capacity, environmental capacity, infrastructure capacity, and public service capacity.The daily water consumption per capital is the single index, far more than the second index, which illustrates that the problems of water resources is the main factor influencing the comprehensive carrying capacity of the prefecture level cities in the Gansu province.

B. The analysis of pressure carrying index

It can be seen from table 2 that, the pressure carrying index of the prefecture-level cities in Gansu province are not identical.In general, the comprehensive capacity pressure pressuring carrying indexes of three cities are more than 1, which respectively are Jiayuguan, Jinchang and Jiuquan.The pressure carrying indexes of other nine cities including the provincial capital Lanzhou are less than 1, which shows that for most of the prefecture-level cities in Gansu province , the main method of improving the urban comprehensive carrying capacity in the future is to improve the carrying capacity.Seen from the perspective of resources pressure carrying index,the jiayuguan city is the highest and longnan city is the lowest;seen from the perspective of environmental pressure carrying index, the highest is the Dingxi city, the lowest is the Jinchang city; From the perspective of economic pressure carrying index, the highest is Dingxi city, the lowest is the Jinchang city; from the perspective of infrastructure pressure carrying index, the pressure index of each city is similar;from the perspective of public service pressure index, it can be seen that most of the cities have low pressure carrying index. Except fo the Jiayuguan city which is above 1, the dat of 10 cities are below 0.5.

C. The analysis of the comprehensive carrying capacity

It can be seen from the table 3 that the comprehensive carrying capacity of the the prefecture-level cities in Gansu province are echeloned, reflecting in that the west is high and the east is low. The standard deviation of the urban comprehensive carrying capacity of the five cities,Jiuquan, Jiayuguan, Jinchang, Baiyin, Zhangye is above the mean value of 0.5, thus belonging to the higher carrying capacity. And the comprehensive carrying capacity of other cities is below the mean value of 0.5. The cities with medium carrying capacity are Lanzhou, Qingyang ($0.42 < A < 0.48$). The urban comprehensive carrying capacity of the five cities, Tianshui, Wuwei, Pingliang, Dingxi, Longnan , are below 0.4 with more than two standard deviations, which shows that these cities belong to low carrying capacity.

Seen from the figure 1, the contribution of each factor system for comprehensive -carrying in each city of Gansu province is

ISBN: 978-1-61804-255-2

not the same.The improvement of the urban comprehensive carrying capacity is a systematic and coordinated process.The weakening of the function of any elements will have great impact on the coordination degree of the whole city system and the decline of the comprehensive carrying capacity.

D. The Lanzhou city and Tianshui city have a weaker guiding ability among the urban agglomeration

The Lanzhou city and Tianshui city are the first and second largest city of Gansu province. They also respectively are the center of the Lanzhou-Xining urban agglomeration the Guanzhong - Tianshui economic zone, playing a leading role in the region.But seen from table 3, the comprehensive ability of Lanzhou city only ranks fourth in the province,and the resource carrying capacity is its short board factor. What is different other big cities is that, the development of Lanzhou city is more limited by the shortage of land resources. While the development problem of Tianshui city is different from Lanzhou's. Tianshui's economic carrying capacity has a large gap with other cities'with a low contribution rate. And its problems of resource carrying capacity are mainly manifested in the shortage of water resources.

V. CONCLUSION

A. Make full use of resources and improve the urban comprehensive carrying capacity

Take the demand for resources and the utilization of resources as breakthrough, reasonably guide demands, and improve the efficiency. Transform the concept of resource utilization of enterprises and residents in daily production and life, implement the system that encourages and rewards saving and gid their reasonable resource demand orientation. Encourage to develop circular economy to realize the efficient utilization of resources, strive to build a conservation-minded society, improve the urban comprehensive carrying capacity.

B. Improve the carrying capacity of system factor according to local conditions and improve urban comprehensive carrying capacity

Seen from the above analysis, the factors affecting the urban comprehensive carrying capacity of the prefecture-level cities in Gansu province are not the same, thus it is necessary to improve the carrying capacity of system factor according to local conditions so as to eventually realize the purpose of improving the urban comprehensive carrying capacity. Take the Lanzhou city as an example, improving the urban comprehensive carrying capacity needs to take promoting resources carrying capacity as the breakthrough and carry out order construction of new city zone through further revitalization and deep mining of the existing land resource.To sum up, when a certain element of the city comprehensive carrying capacity system becomes short slab, not only its breakthrough needs to be considered, the further optimization of the system structure also should be considered.

C. Steadily push forward the urbanization process, improve the quality of urbanization, guide the reasonable distribution of population, form reasonable structure of the urban comprehensive carrying space carrier

The prefecture-level cities of Gansu province have become the important front for acceptance of the transferring rural population. But it can be seen from the analysis that the urban resource utilization efficiency is low with the problems of waste of land expansion, environmental problems, lack of infrastructure and public service ability existing, which shows that the urban development pattern has certain problems. It is suggested that the future population distribution not be too concentrated in the big cities so as to alleviate the pressure of the big city. Under policy guidance,the population transfer can be concentrated in small and medium-sized cities, thus enhancing the connotation of the city.

REFERENCES

[1] Sun Chunhua. Research on Comprehensive Evaluation of Carrying Capacity about Prefecture-level City in Inner Mongolia. Journal of Finance and Economics Theory. 2013(5):81-87

[2] Oh K, Jeong Y, Lee D, et a.l An Intergrated Framework for the Assessment of Urban Carrying Capacity . Korea Plan Assoc,2002,37(5):7-26.

[3] United States Environmental Protection Agency. Four Townships Environmental Carrying Capacity Study. 2002,

[4] Yu Weidong Min Qingwen. Some Progresses and Perspectives in Study on the Carrying Capability of Water Resources. ARID ZONE RESEARCH,2003,20(1):60-66.

[5] CHENG Li-li L(U) Cheng-wen XU Guo-lin. Study on Population Supporting Capacity of Land Resources in Anhui Province. RESOURCE DEVELOPMENT & MARKET ,2006,22(4): 318-320.

[6] Zhu Yizhong Xia Jun. Assessment of water resources carrying-capacity with multi-criteria scenario analysis method: a case study in Zhangye region. GEOGRAPHICAL RESEARCH,2005, 24(5): 732-740.

[7] Song Xiaomeng, Kong Fanzhe, Zhan Chesheng. Assessment of water resources carrying capacity in Tianjin City of China.Water Resources Management, 2011, 25: 857-873.

[8] Cang Hui. Carrying capacity, population equilibrium, and environment's maximal load. Ecological Modelling, 2006, 192:317-320.

[9] LV Guangming HE Qiang. A Study on Urban Comprehensive Carrying Capacity under Sustainable Development Theory. URBAN STUDIES,2009,16(4):1-3.

[10] LONG Zhihe, REN Tongxian, LI Min and HU Guiping. The research of city carrying capacity of Cuangzhou. SCIENCE AND TECHNOLOGY MANAGEMENT RESEARCH,2010,30(5):204-207.

[11] L IU Xiaoli and FANG Chuanglin. Progress and Prospect of Study on Carrying Capacity of Resource and Environment of City Clusters. PROGRESS IN GEOGRAPHY ,2008,27(5):35-42.

[12] OU Chao-min and LIU Ren-yang.Evaluation of Urban Synthetic Carrying Capacity of the Chang-Zhu-Tan Urban Agglomerations. JOURNAL OF NATURAL SCIENCE OF HUNAN NORMAL UNIVERSITY, 2009,32(3):108-112.

[13] CHEN Juan LI Jing-bao QING Xiong-zhi. Evaluation on Urban Comprehensive Carrying Capacity of "3+5" Urban Agglomeration of Hunan Province. TERRITORY & NATURAL RESOURCES STUDY 2010,(3):69-74.

[14] Buckley R. An ecological perspective on carrying capacity[J].Annals of Tourism Research,1999,(03):705-708.

[15] GAO Hong-li TU Jian-jun and YANG Le. Evaluation of the Comprehensive Carrying Capacity of Cities. JOURNAL OF SOUTHWEST UNIVERSITY(NATURAL SCIENCE),2010.

[16] Gu Chaolin, Zhen Feng. Synthesized Evaluation of Capacity of Sustainable Development of Cities in Jiangsu Province. JOURNAL OF NANJING UNIVERSITY(NATURAL SCIENCES). 2001 7(3)

[17] YANG Li-hua HE Xue-feng. On the Sustainable Development Index of Trade Based on Entropy Method-Exemplified by the Empirical Research of Zhejiang Province. JOURNAL OF NINGBO UNIVERSITY(LIBERAL ARTS EDITION),2007(1):22-24.

[18] SUN Li, L(U) Bin and HU Jun. Urban Carrying Capacity Evaluation of Zhongyuan city Agglomeration. AREAL RESEARCH AND DEVELOPMENT.2008(6):16-20

Table.1 Evaluation index systems of urban comprehensive carrying capacity of the refecture-level city in Gansu Province

Target layer	Base layer	Criterion layer	Index layer
Urban comprehensive carrying capacity a	Resources carrying capacity b1 0.3075	Pressure index 0.1944	Per capita daily water consumption c1 0.1001
			Comprehensive energy consumption c2 0.0943
		Pressure carrying index 0.1131	Per capital construction land area c3 0.0415
			Total water resources c4 0.0728
	Environmental carrying capacity b2 0.1847	Pressure index 0.034	The proportion of the days when the air quality reaches or above the second level in one year c5 0.0216
			Sewage emissions c6 0.0124
		Pressure carrying index 0.1507	Green coverage ratio of construction land area c7 0.0809
			Processing capacity of municipal sewage plant per day c8 0.0698
	Economic capacity b3 0.2142	Pressure index 0.1297	Per capita gdp pc9 0.0705
			Proportion of primary industry c10 0.0592
		Pressure carrying index 0.0845	Proportion of tertiary industry c11 0.0413
			Growth rate of gross value of production c12 0.0432
	Infrastructure capacity b3 0.1643	Pressure index 0.0759	Per capita road area c13 0.0501
			Transportation amount of household refuse c14 0.0258
		Pressure carrying index 0.0884	The proportion of classified highway c15 0.0438
			The number of buses per ten thousand persons c16 0.0446
	Public service capacity b4 0.1293	Pressure index 0.0578	Number of bed in health agency per ten thousand persons c17 0.0251
			The proportion of the person who have the lowest living ensure in the cities and towns c18 0.0148
			Primary and secondary school enrollment c19 0.0179
		Pressure carrying index 0.0715	The proportion of the person participating in new rural cooperative medical system c20 0.0098
			The proportion of the medical treatment and public health expenditure in each area c21 0.0286
			The proportion of the education expenditure in each area c22 0.0331

Table.2 The pressure-carrying index of urban comprehensive carrying capacity of the refecture-level city in Gansu Province

Area	resources pressure carrying index	Environmental pressure carrying index	economic pressure carrying index	infrastructure pressure carrying index	public service pressure carrying index	urban comprehensive carrying capacity pressure carrying index
Lanzhou	0.48812	0.49395	0.21186	1.16654	0.28120	0.92730
Jiayuguan	1.20267	0.11739	0.07546	1.15813	1.65863	1.84320
Jinchang	0.89133	0.08263	0.07828	1.15716	0.96980	1.53113
Baiyin	0.57339	0.22621	0.15509	1.16210	0.30970	0.96405
Tianshui	0.26019	0.51621	0.51679	1.15967	0.20215	0.68492
Wuwei	0.32454	1.42605	0.29218	1.15917	0.22667	0.75078
Zhangye	0.62585	2.44142	0.18114	1.15621	0.29181	0.95697
Pingliang	0.46513	0.85420	0.36989	1.16057	0.22434	0.79130
Jiuquan	0.73667	0.33471	0.13035	1.15341	0.38058	1.11419
Qingyang	0.37449	0.79551	0.20158	1.16175	0.25355	0.80511
Dingxi	0.35204	3.32301	0.79569	1.15869	0.19820	0.70291
Longnan	0.23569	2.09464	0.66957	1.15590	0.19533	0.66407

Table.3 The analysis of factors carrying capacity and urban comprehensive carrying capacity of the refecture-level city in Gansu Province

Area	Resources Carrying Capacity	Environmental Carrying Capacity	Economic Carrying Capacity	Infrastructure Carrying Capacity	Public Service Carrying Capacity	Urban Comprehensive Carrying Capacity	Ranking
Lanzhou	0.08681	0.05465	0.16252	0.05517	0.10979	0.46894	6
Jiayuguan	0.11377	0.05226	0.34437	0.04686	0.03281	0.59008	3
Jinchang	0.10456	0.05394	0.34704	0.04877	0.04328	0.59760	2
Baiyin	0.09976	0.06085	0.21475	0.05606	0.10316	0.53458	4
Tianshui	0.06117	0.04509	0.06271	0.04153	0.10754	0.31804	10
Wuwei	0.07059	0.04996	0.10496	0.04616	0.10870	0.38037	8
Zhangye	0.10195	0.05995	0.18564	0.05531	0.10681	0.50966	5
Pingliang	0.07709	0.04981	0.08760	0.04604	0.10934	0.36988	9
Jiuquan	0.11921	0.06403	0.26595	0.05948	0.09427	0.60294	1
Qingyang	0.08024	0.05481	0.15273	0.04988	0.10724	0.44490	7
Dingxi	0.06500	0.04445	0.04723	0.04075	0.10720	0.30463	11
Longnan	0.05827	0.04384	0.05133	0.04011	0.10683	0.30037	12

Social Capital and Organizational Sustainability: Case of Malaysian SMEs

Chaudhry Shoaib Akhtar, Kamariah Ismail and Jawad Hussain

Abstract**—**SMEs due to their size and resources are vulnerable to sudden economic changes. Large numbers of SMEs disappear within first five years of their operations and to remain operational these small enterprises need to position themselves in such a way to cater for the needs of the ever changing customer demands. The present study is an attempt to investigate the relationship and influence of social capital and its three dimensions on the sustainability of SMEs in Malaysia. The results indicate that social capital as a construct has a significant relationship and influence on sustainability of SMEs. However, multiple regression results indicate that structural and relational social capital have significant influence on sustainability but cognitive social capital is insignificant. The results are significant for the owners/managers of SMEs and how they operate their enterprises. Future recommendations are also provided for researchers interested in the subject area.

Keywords**—**Malaysia, SMEs, Social capital, Sustainability.

I. Introduction

In today's complex business environment, organizations are in pursuit of sustainability. Where this race has created challenges, organizational apprehensions are also increasing. With the economy becoming more and more knowledge oriented it is becoming difficult for small and medium enterprises (SMEs) to remain competitive and sustain over a longer period of time. SMEs need to position themselves in such a way so as to cater for the changing needs and expectations of their customers for new and improved products. To achieve these ends, it is imperative that SMEs start strategizing in a way as to make them sustainable in the wake of changing business environment.

SMEs due to their smaller size and resource portfolio are vulnerable to sudden economic changes [1] that results in the failure of the small enterprises. Large number of studies indicate that majority of the small firms disappear within the first five years of their operation [2][3][4][5], mainly because of factors like in-competencies of the owner/manager [6][7][8][9]; lack of personal contacts and network with the customers [10][11][12]; lack of financial resources [8][13][14], to name a few.

Ch. Shoaib Akhtar is PhD scholar in Faculty of Management at Universiti Teknologi Malaysia, Johor, Malaysia. (Ph. +60-137411139; email: sachaudhry2@live.utm.my).

Kamariah Ismail is Associate professor in Faculty of Management at Universiti Teknologi Malaysia, Johor, Malaysia. She is also the Director of Technology Entrepreneurship Center, UTM (UTMTEC) (m-maria@utm.my).

Jawad Hussain is PhD scholar in Faculty of Management at Universiti Teknologi Malaysia, Johor, Malaysia. (jawadhussain79@gmail.com).

Malaysia being a fast developing country relies heavily on SMEs. SMEs account for 97.3% of total business establishments with GDP contribution of 32.5% [1]. Despite Malaysian government's focus on developing SMEs, the failure rate is approximately 42%. Ahmed and Seet [10] have cited a figure of 60% for failure among Malaysian SMEs. They further point out that the major reason for such a high failure is lack of personal contacts and failure to maintain close relationships with customers.

For sustainability, three interacting aspects are necessary: social, economic and environmental [15][16]. These three aspects, though indpendent are interrelated with eachother. Malaysia, being fast developing country and aspiring to be in high income group of nations by 2020, is aware of the impact of these three aspects of sustainability. The Malaysian government has embarked on various initiavtives and has allocated sizeable funds for promotion of sustainability for economic development of the country and achieving 2020 vision in its 10th Malaysia Plan. However, researchers have highlighted that despite Malaysian government's efforts, SMEs are still facing many problems such as lack of financing, low productivity, lack of managerial capabilities, low skilled workforce, inability to adopt technology, lack of information on potential markets and customers and global competition [17][18][19][20][21][22].

One of the important factors in the sustainability of organizations is the social capital. Social capital is the intangible asset of an organization that comprises of networks, trust and reciprocity that exist between employees as well as between organizations [23][24][25]. Research suggests that entrepreneurs should be trained on developing the heterogeneous business linkages and government should also provide a platform where collaboration between these linkages can take place [26]. A strong social capital with its heterogeneous linkages is deemed necessary for the growth, innovativeness and sustainability of small and medium enterprises in this competitive world [27][28][26]. Researchers are of the view that the success of organizations depend on the networks that may simultaneously be competitive as well as cooperative, which enable and sustain beneficial creative activity [29] and helps in innovation to attain competitive position [30] that ultimately leads to sustainability of organizations. Furthermore, research highlights that industry-academic linkage has a strong influence on the innovative capabilities of organizations, the greater and stronger these linkages and ties are the greater the growth potential of SMEs [31].

ISBN: 978-1-61804-255-2

The present study is an attempt to highlight the influential role of social capital in the sustainability of small and medium enterprises.

II. Literature Review

Social capital (SC) is a multi-dimensional concept [25] as such various researchers have defined it differently. The concept has been in vogue since 1916 when Hanifan first coined the phrase. According to Hanifan [32] SC is reflected by goodwill, fellowship, mutual sympathy and social intercourse. Putnam [33] a well known scholar in the field of SC reflects it in terms of norms, networks and trust, whereas, Nahapiet and Ghoshal [24] define SC in terms of networks, relationships and norms. According to them networks of employees reside within structural social capital of the organization; relationships are viewed within the context of relational social capital and norms and values of an organization are embedded within the cognitive social capital. Fukuyama [23] relates SC with norms of reciprocity that exists between two or more individuals. Coleman [34] views social capital as an asset stemming from access to resources made available through social relationships. Whichever definition researchers use the overall theme that emerges is that SC is reflected by trust, reciprocity, network of relationships, norms and values that exist between individuals and organizations within any society.

The concept of sustainability has been associated with Wes Jackson's work on agriculture [35] and later on incorporated by Brundtland Commission Report under the auspices of the United Nations Commission on Environment and Development (WCED). The report defined sustainability in terms of development of the human ecology as 'development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs' [36]. This report encompassed the holistic concept of sustainability from social to economic to environmental as we know it today.

In terms of business organizations, sustainability refers to as the meeting the needs of an organization's direct and indirect stakeholders such as shareholders, employees, clients, communities etc, without compromising its ability to meet the needs of future stakeholders as well. To attain this organizations have to maintain and grow their economic, social and environmental capital base while actively contributing to sustainability in the political domain [37].

Lee [38] is of the opinion that organizational sustainability can be achieved if strong inter-organizational linkages are present. These linkages provide complementary strengths and create value for the organizations to achieve sustainable advantage. These linkages not only help the employees and organizations alike to share knowledge but also help in the development of competencies that are necessary for the sustainability [39]. With the globalization and the advent and impact of information technologies, organizations under the changing and uncertain environment, develop interactional activities at three levels or dimensions: the global interaction, a local interaction at a given geographic zone and a space of influence covering interaction of the organization the other organizations through two information networks: formal information network between internal and external entities through data circulation and explicit knowledge exchange and informal information network between employees favoring information sharing and tacit knowledge sharing. These networks help employees not only to enhance their competencies but also help them to take decisions and actions under uncertain situations and circumstances [40].

The development of domestic SMEs is crucial for overall economic development, which can be achieved by promoting entrepreneurship and reducing risk by facilitating access to finance, skills, business development services, appropriate technologies, and market information and helping SMEs to forge effective linkages with larger and foreign enterprises which dominate regional and global value chains and production networks [41]. Gronum, et al., [28] are of the view that unless networks are utilized optimally efforts to create and maintain these networks would be useless. Therefore, SME owners and managers should utilize their limited resources in establishing diverse and strong network links that could help them grow. These strong networks would establish trust [34][42] that would enable SMEs to obtain advantages of larger size [28][43]. Furthermore, networks provide SMEs with more access to resources, complementary skills, capabilities and knowledge that are not internally available and are deemed necessary for sustained growth [44].

Research highlights that quality of personal relationships with customers and business partners is critical for SMEs as they rely on their personal networks and reputation to attract customers in the absence of large marketing budgets [45]. Loucks, et al., [45] further point out that SMEs especially older firms and family businesses can benefit from large amounts of social capital for their sustainability. Putnam [33][46] argues in support for larger social capital that helps in decreasing the cost of doing business in communities. The lower costs are attributed to strong sense of community among stakeholders that leads to a greater level of trust.

Networks are helpful and play a vital role in ensuring success of SMEs [47]. Halila [47] further highlights that networks can provide SMEs with expertise and resources that can help them to take risks and implement sustainable practices they might otherwise have not considered. These networks further provide support to SMEs in generating and developing new ideas and implementing strategies. These networks should be key element for development of sustainability strategies and acquisition of information and knowledge regarding sustainability practices by the SMEs [45].

III. Methodology

For the study sample consists of enterprises registered with the Malaysian Federation of Manufacturers (FMM). The sample size of the study was 335 consisted of both service and manufacturing SMEs in Malaysia. The unit of analysis was organization because normally social capital for an organization emerges from the interactions of individuals representing their organizations. Furthermore, sustainability is for the organization. Thus keeping these two considerations, organization was the unit of analysis. The respondent chosen to represent organization were the CEOs, Managing Directors, managers or their proxies. Their proxies were chosen because of the commitments top management has, it was hard to get their response. Therefore, on their discretion they could appoint a proxy to answer the questions.

The instrument for the study was developed after doing a thorough literature review. The self administered questionnaire consisted of social capital (17 items) which represented three dimensions of structural, relational and cognitive social capital; sustainability (41 items) representing three dimensions social, economic and environmental sustainability.

The survey data was collected through two sources: web based questionnaire and face to face submission of questionnaire. The collected questionnaires that were finally used in the analysis were 171, depicting a response rate of 51 percent. The instrument was subjected to factor analysis using PCA in SPSS 21. The factor loadings for the items measuring the variables of the study indicated that the instrument was valid and reliable for further statistical analysis. The analysis was conducted using Pearson correlation and regression. Before subjecting the data to regression, assumptions of regression analysis were satisfied.

IV. RESULTS AND DISCUSSION

Pearson correlation was used to ascertain the relationship between social capital and its dimensions with sustainability. The results are shown in Table 1.

Table 1. Correlation matrix

Variable	SC	SSC	CSC	RSC
Sustainability	0.622**	0.564**	0.547**	0.545**
**Correlation significant at 0.01 level				

The correlation result indicates that there is a strong and positive relationship between sustainability and social capital. Furthermore, the results also show that dimensions of social capital: structural, cognitive and relational social capital have strong and positive relationship with sustainability.

To investigate the influence of social capital and its dimensions on sustainability, regression analysis was performed. For social capital simple linear regression analysis indicated that social capital has a significant influence on sustainability of organization ($\beta = 0.545$, $p < 0.05$). Similarly, to check the influence of each dimension of social capital on sustainability, multiple regression was applied. The results indicate that structural social capital ($\beta = 0.273$, $p < 0.05$) and relational social capital (($\beta = 0.189$, $p < 0.05$) are having strong and statistically significant influence on sustainability. However, cognitive social capital ($\beta = 0.109$, $p > 0.05$) is found to be insignificant. The regression results are shown in Table 2.

Table 2. Regression for SC and Sustainability Model

Model	R	R^2	Adj. R^2	β	*t*	Sig.
SC	.622	.387	.383	.545	10.797	.000
F 116.570, p<0.01						
SSC	.627	.393	.383	.273	3.681	.000
CSC				.109	1.625	.106
RSC				.189	2.995	.003
F 39.432, p<0.01						

The results of the study signify the importance of social capital in the sustainability of small and medium enterprises. Literature also highlights that strong networks not only help organizations to sustain themselves but also provide them with resources that are much needed by the smaller organizations and are not available internally [28][38][42][43][44].

Structural social capital relates to the pattern of relationships that exist within and outside of the organization [24][48][49] and are considered to be assets of an organization as they provide access to resources and information [34]. Relational social capital relates to the trust and reciprocity that exists within and outside of the organization. This trust is important for organizations to access resources and competences available in other organizations and not present internally. Thus, relationships built over a period of time are not only strong but also help in the adaptability to changing environment [48][51][52][53][54].

The regression results indicate that the quality of network and its configuration is important for organizational sustainability. If the network quality is strong it will not only provide much needed resources but would also provide information and knowledge that can be crucial for the sustainability of an organization. The results further indicate that the organizations have strong relationships with other organizations, which are based on trust and reciprocity.

However, regression result related to cognitive social capital is telling another story. Cognitive social capital relates to sharing of resources through communication and dialogue [49]. Isaac [50] highlights that dialogue can create an environment where people continuously interact with each other to create shared meaning. This shared meaning develops common understandings and collective ideologies for mutual benefits [55]. Inkpen and Tsang [56] are of the view that cognitive social capital is composed of shared culture and

ISBN: 978-1-61804-255-2

congruent goals. Explaining these shared culture and goals, [51] highlights that shared culture is the norms of behavior that govern the relationship; while congruent goals represents common understanding to achieve common tasks and objectives. Goal congruence is more important for a longer term association between relationships [57], without which there may be conflicts [56] and lack of organizational development [58]. The regression result indicates that cognitive social capital is insignificant, indicating that there is low level of goal sharing among the organizations, which is making cognitive aspect insignificant. Furthermore, the result indicates that organizations do not consider cognitive aspect to be important in their sustainability efforts.

V. CONCLUSION

The study is important for small and medium organizations because of the resource constraints they have in terms of human resources, competencies, knowledge & information. Developing networks within their circles can not only help them bridge the gaps in terms of resources but would also help them to develop and sustain themselves for longer period of time. However, organizations need to develop strong social capital along with its dimensions. The study results indicate that structural and relational social capitals are more valued by organizations in relation to cognitive social capital, without realizing that cognitive aspect plays more important role by identifying common threads for building stronger relations along with developing trust. Thus, if organizations want to develop stronger relations with others, they need to have and develop common goals, which can bring them closer together. Such relationship would not only help them grow but would also help in their sustainability.

Organizational sustainability is an important issue especially for smaller organizations. The increased rate of failure among smaller organizations stresses the need for further studies. There are a number of studies that have taken into account management perspectives related to strategies, marketing, finance, economics, but limited numbers of studies go beyond these aspects. Social capital is one area which can be explored further in detail to evaluate its relevance in sustainability. Social capital is a well researched area in community development but in organizational science it needs to make its mark. Future studies can go further into detail and investigate the relationship of individual dimension of social capital with individual dimension of sustainability. Linking individual social capital dimension with social, economic and environmental sustainability would definitely help us in understanding the nature and role of social capital in organizational sustainability. Furthermore, comparative researches can be done between sectors or cross cultural/country comparisons can yield more information and knowledge regarding the constructs. Other factors such as leadership, culture, HR practices and policies etc that can influence social capital or sustainability may also be studied along with the study constructs.

REFERENCES

[1] SMEAR. (2012). *SME Annual Report 2011-12*. Kuala Lumpur: National SME Development Council.
[2] Cook, R., Campbell, D., & Kelly, C. (2012). Survival Rates of New Firms: An Exploratory Study. *Small Business Institute® Journal, 8*(2), 35-42.
[3] Kuratko, D., & Hodgetts, R. (2004). Entrepreneurship: Theory, Process and Practice. 2004. *Mason, Ohio: Thomson*.
[4] Shane, S. (2012). Small Business Failure Rates by Industry: The Real Numbers. from smallbiztrends.com.
[5] Zimmerer, T., Searborough, N., & Wilson, D. (2008). Essential of entrepreneur1/2ship and small business management: New Jersey: Prentice Hall, Upper Saddle River.
[6] Beaver, G., & Jennings, P. (2005). Competitive advantage and entrepreneurial power: The dark side of entrepreneurship. *Journal of Small Business and Enterprise Development, 12*(1), 9-23.
[7] Clusel, S., Guarnieri, F., Martin, C., & Lagarde, D. (2013). *Assessing the vulnerability of SMEs: a qualitative analysis*. Paper presented at the 22nd European Safety, Reliability and Risk Analysis: Beyond the Horizon.
[8] Ihua, U. B. (2009). SMEs key failure-factors: a comparison between the United Kingdom and Nigeria. *Journal of Social Sciences, 18*(3), 199-207.
[9] Kiggundu, M. N. (2002). Entrepreneurs and entrepreneurship in Africa: What is known and what needs to be done. *Journal of developmental entrepreneurship, 7*(3), 239-258.
[10] Ahmad, N. H., & Seet, P.-S. (2009). Dissecting behaviours associated with business failure: A qualitative study of SME owners in Malaysia and Australia. *Asian Social Science, 5*(9), 98-104.
[11] Lee, H., Kelley, D., Lee, J., & Lee, S. (2012). SME survival: The impact of internationalization, technology resources, and alliances. *Journal of Small Business Management, 50*(1), 1-19.
[12] Teoh, W. M.-Y., & Chong, S. (2008). Improving women entrepreneurs in small and medium enterprises in Malaysia: policy recommendations. *Communications of the IBIMA, 2*(5), 31-38.
[13] Ting, O. (2004). SMEs in Malaysia: Pivot points for change. *on line available at http://www. mca. org. my*.
[14] Wang, S. (2003). The development of e-financing: implications for SMEs. *Bulletin on Asia-Pacific Perspectives, 4*, 77-84.
[15] Dale, A. (2001). *At the Edge: Sustainabile Development in the 21st Century*. Vancouver: UBC Press.
[16] Danchev, A. (2006). Social Capital and Sustainable Behavior of the Firm. *Industrial Management & Data Systems, 106*(7), 953-965.
[17] Hashim, F. (2012). Challenges for the Internationalization of SMEs and the Role of Government: The Case of Malaysia. *Journal of International Business and Economy, 13*(1), 97-122.
[18] Hoq, M. Z., Ha, N. C., & Said, S. M. (2009). SMEs in the Malaysian Economy. *International Journal of Marketing Studies, 1*(2), 3-17.
[19] Kee-Luen, W., Thiam-Yong, K., & Seng-Fook, O. (2013). *Strategic Planning and Business Performance: A Study of SMEs in Malaysia.* Paper presented at the 3rd Asia-Pacific Business Research Conference, 25-26 February, Kuala Lumpur, Malaysia.
[20] Saleh, A. S., Caputi, P., & Harvie, C. (2008, 2-3 August). *Perceptions of Business Challenges Facing Malaysian SMEs: Some Preliminary Results.* Paper presented at the 5th International Conference on SMEs in Global Economy, Tokyo, Japan.
[21] Saleh, A. S., & Ndubisi, N. O. (2006). An Evaluation of SME Development in Malaysia. *International Review of Business Research Papers, 2*(1), 1-14.
[22] Wang, S.-D. (2004). The Development of E-financing: Implications for SMEs *Bulletin on Asia-Pacific Perspectives 2003-2004: Asia-Pacific Economies Maintaining Dynamism* (pp. 77-84). Bangkok, Thailand: United Nations.
[23] Fukuyama, F. (2001). Social Capital, Civil Society and Development. *Third World Quarterly, 22*(1), 7-20.
[24] Nahapiet, J., & Ghoshal, S. (1998). Social Capital, Intellectual Capital, and the Organizational Advantage. *The Academy of Management Review, 23*(2), 242-266.
[25] Putnam, R. D. (2001). Social Capital: Measurement and Consequences. *Canadian Journal of Policy Research, 2*(1), 41-51.
[26] Jafri, S. K. A., Ismail, K., Khurram, W., & Soehod, K. b. (2014). Impact of Social Capital and Firms' Innovative Capability on Sustainable

Growth of Women Owned Technoprises (SMEs): A Study in Malaysia. *World Apllied Sciences Journal, 29*(10), 1290-2014.

[27] Fanfan, Y. (2011). *Insights into Social Network Theory and Entrepreneurship*. Paper presented at the International Conference on Management and Service Science (MASS), 12-14 August, Wuhan, China.

[28] Gronum, S., Verreynne, M.-L., & Kastelle, T. (2012). The Role of Networks in Small and Medium Enterprise Innovation and Firm Performance. *Journal of Small Business Management, 50*(2), 257-282.

[29] Schebesch, K. B. (2012). *Enabling IC Formation in Composite Organizations - The Action of Trust and Reputation Mechanisms*. Paper presented at the 4th European Conference on Intellectual Capital: ECIC 2012, 23-24 April, Helsinki, Finland.

[30] Kramer, J.-P., Marinelli, E., Iammarino, S., & Diez, J. R. (2011). Intangible Assets as Drivers of Innovation: Empirical Evidence on Multinational Enterprises in German and UK Regional Systems of Innovation. *Technovation, 31*(9), 447-458.

[31] Santos-Rodrigues, H., Gonzalez-Loureiro, M., & Figueroa-Dorrego, P. (2012). *System of Innovation and Innovative SMEs: A Model to Measure the Intellectual Capital of SMEs*. Paper presented at the 4th European Conference on Intellectual Capital: ECIC 2012, 23-24 April, Helsinki, Finland.

[32] Hanifan, L. J. (1916). The Rural School Community Center. *Annals of the American Academy of Political and Social Science, 67*, 130-138.

[33] Putnam, R. D. (1993). The Prosperous Community: Social Capital and Public Life. *The American Prospect, 4*(13).

[34] Coleman, J. S. (1990). *Foundations of Social Theory*. Cambridge, MA: Belknap.

[35] Jackson, W. (1980). *New Roots for Agriculture*. Berkeley, California: North Point Press.

[36] WECD. (1987). *Our Common Future*. New York: United Nations World Commission on Environment and Development.

[37] Dyllick, T., & Hockerts, K. (2002). Beyond the Business case for Corporate Sustainability. *Business Strategy and the Environment, 11*(2), 130-141.

[38] Lee, L. L. (2009). *IT Governance in a Networked World: Multi-Sourcing Strategies and Social Capital for Corporate Computing*. Hershey, PA: Information Science Reference.

[39] Bennet, A., & Bennet, D. (2010). Multidimensionality: Building the Mind/Brain Infrastructure for the Next Generation Knowledge Worker. *On The Horizon, 18*(3), 240-254.

[40] Rosenthal-Sabroux, C., & Grundstein, M. (2008). A Knowledge Management Approach of ICT. *VNU Journal of Science, Natural Sciences and Technology, 24*(2), 162-169.

[41] UNESCAP. (2013). *Asia-Pacific Trade and Investment Report 2013: Turning the Tide: Towards Inclusive Trade and Investment*. New York: United Nations Economic and Social Commission for Asia and The Pacific.

[42] Ahuja, G. (2000). Collaboration networks, structural holes, and innovation: a longitudinal Study. *Administrative Science Quarterly, 45*(3), 425-455.

[43] Gilsing, V., & Nooteboom, B. (2005). Density and Strength of Ties in Innovation Networks: An Analysis of Multimedia and Biotechnology. *European Management Review, 2*(3), 179-197.

[44] Doving, E., & Gooderham, P. N. (2008). Dynamic Capabilities as Antecedents of the Scope of Related Diversification: The Case of Small Firm Accountancy Practices. *Strategic Management Journal, 29*(8), 841-857.

[45] Loucks, E. S., Martens, M. L., & Cho, C. H. (2010). Engaging Small and Medium Sized Busineses in Sustainability. *Sustainability Accounting Management and Policy Journal, 1*(2), 178-200.

[46] Putnam, R. D. (1995). Bowling Alone: America's Declining Social Capital. *Journal of Democracy, 6*(1), 65-78.

[47] Halila, F. (2007). Networks as a Means of Supporting the Adoption of Organizational Innovations in SMEs: The Case of Environmental Management Systems (EMSs) Based on ISO 14001. *Corporate Social Responsibility and Environmental Management, 14*(3), 167-181.

[48] Bolino, M. C., Turnley, W. H., & Bloodgood, J. M. (2002). Citizenship Behavior and the Creation of Social Capital in Organizations. *The Academy of Management Review, 27*(4), 505-522.

[49] Chang, S.-C., Chiang, C.-Y., Chu, C.-Y., & Wang, Y.-B. (2006). The Study of Social Capital, Organizational Learning, Innovativeness, Intellectual Capital and Performance. *The Journal of Human Resource and Adult Learning, 2*(2), 64-71.

[50] Isaacs, W. N. (1993). Taking Flight: Dialogue, Collective Thinking, and Organizational Learning. *Organizational Dynamics, 22*(2), 24-39.

[51] Villena, V. H., Revilla, E., & Choi, T. Y. (2011). The Dark Side of Buyer-Supplier Relationships: A Social Capital Perspective. *Journal of Operations Management, 29*(6), 561-576.

[52] Bendoly, E., Croson, R., Goncalves, P., & Schultz, K. (2010). Bodies of Knowledge for Research in Behavioral Operations. *Production and Operations Management, 19*(4), 434-452.

[53] Cousins, P. D., & Menguc, B. (2006). The Implications of Socialization and Integration in Supply Chain Management. *Journal of Operations Management, 24*(5), 604-620.

[54] Carey, S., Lawson, B., & Krause, D. (2011). Social Capital Configuration, Legal Bonds and Performance in Buyer-Supplier Relationships. *Journal of Operations Management, 29*(4), 277-288.

[55] De-Carolis, D. M., & Saparito, P. (2006). Social Capital, Cognition, and Entrepreneurial Opportunities: A Theoretical Framework. *Entrepreneurship Theory and Practice, 30*(1), 41-56.

[56] Inkpen, A. C., & Tsang, E. W. K. (2005). Social Capital, Networks, and Knowledge Transfer. *Academy of Management Review, 30*(1), 146-165.

[57] Jap, S. D., & Anderson, E. (2003). Safeguarding Interorganizational Performance and Continuity Under Ex Post Opportunism. *Management Science, 49*(12), 1684-1701.

[58] Holcomb, T. R., & Hitt, M. A. (2007). Toward a Model of Strategic Outsourcing. *Journal of Operations Management, 25*(2), 464-481.

Residential choice in different countries: Maslow and culture

Maia Ozdemir

***Abstract*—** Construction industry has some unique features (fragmentation, for instance) that make applying marketing difficult. However, increasing competition in construction industry compels companies to change their views toward customers' expectations and to adopt new customer friendly marketing strategies. Effective marketing is beneficial for construction companies. Customer centered strategy becomes even more important in multicultural environment. Because of migration, it is difficult to find a place without migrants in the world, and all big cities became multicultural metropolises. So, almost every company should consider itself acting on multicultural market. Multiculturalism leads to the new segment of housing market. Every company interested in capitalizing on this new lucrative market should recognize customers' cultural needs and develop the new marketing strategy accordingly. Moreover, the fact, that ignoring humanistic factors in build environment has psychopathological consequence called "uprootedness", carries this problem up to the level of government. Maslow's hierarchy of needs is useful for customers' segments definition and segmental marketing strategy development. Based on Author's previous research, this work attempts to investigate the effects of Maslow's hierarchy of needs on housing preferences and on intercultural marketing strategy. The current work would be interesting for professionals and academics in the field of construction management and building studies.

***Keywords*—**Construction, Culture, Housing preferences, Intercultural Marketing, Maslow.

I. Background

PEOPLE always shaped environment around since the time of early civilization when the first simple buildings were erected from mud. Building structures became the setting for conducting everyday routines and chores, places where people spent their entire lives. Every civilization had its own way of building structures to meet all needs of the group, including cultural, ritual and other needs. Building structures allow scientists to learn a lot about traditions, culture and life of inhabitants.

The official authority to shape the environment nowadays is given to the professional architects. They have the license to organize the form and structure of buildings that enable the carrying out certain functions according to needs of the occupants. So, the performance of built environment depends on the ability of the architects to make appropriate decisions regarding the needs of the end users. Architectural scientists in 80th made the first attempts of research on relation of human motivation factors to housing design but their several studies remained clearly insufficient. For example, Norberg-Schulz (1985) stressed inability of current houses to fully satisfy the needs of residents particularly in terms of figural quality and spatial images [8]. Bachelard (1994) mentioned a lack of meaningful forms in modern houses [1]. According to Rapoport (2000), culture is determinant of a user's housing preferences and choices [12]. Oliver (2006) either highlighted necessity of vernacular architecture that implicates local culture on housing design [9]. Slight increase in number of studies in this area in last few years shows growing awareness in architectural community of importance of implication humans motivation factors in housing design. Jusan (2010) considered person-environment congruence (PEC) central in creating a sense of home [5]. Zavei & Jusan investigated consequences of ignoring human motivational factors in housing provision and advised using Maslow's hierarchy of needs in housing design process. The authors blamed modern life styles and related social facts for critical psychopathological consequence called "uprootedness" in result of the lack of attention to human motivations in the housing provision process. According to Zavei & Jusan (2012), house has become an economic product, and consideration of humanistic aspects of a living environment has gradually decreased [13]. The reasons and consequences of ignoring these factors in build environment design are shown below (Fig.1).

As behavior and motivation are inter-related concepts, famous Maslow's hierarchy of needs is very helpful in interpreting people's and, particularly, homebuyers' behavior.

Maslow (1970) considered culture as a reflection of a person's motivations in response to the effects of external agents imposed from natural and built environment [7] (Fig. 2). According to Maslow (70), there are five levels of cognitive needs, including physiological, safety, belongingness - love, esteem needs, and the need for self-actualization. Gratifying these basic needs in equal measure leads to formation a perfect and healthy man, thwarting the response to these needs leads to psychopathological results. Maslow (1970) considered these basic needs as the origins of every humanistic issue [7]. As soon as a certain needs are gratified people will aspire to go up to upper level of cognitive needs. Zavei & Jusan (2012) argued that understanding these basic needs is also vital in the context

Maia Ozdemir is PhD Candidate in Tomas Bata University in Zlin, 76001 CZE (phone: 905436626177; e-mail: ozdemir@fame.utb.cz, maia.ozdemir@ windowslive.com).

of providing housing [13]. Several studies investigated link between Maslow's hierarchy of needs and built environment. Israel (2003) used "Sociogram exercise" technique based on Maslow's hierarchy of needs for drawing a map of a user's childhood living spaces for identification of the character of a place from the users' environmental roots and imagination [4]. However, the technique hardly may be applicable if the end users are not known such as in mass housing projects. McCray and Day (1977) suggested that user's satisfaction in a house depends on economic or social status, which are higher psychological expectations but urban public housing units can only provide for the physiological needs of the residents [6].

Banham (2007) and Oliver (2006a) suggested classification of residential spaces into three levels namely shelter, house, and home; and a home is much more than a physical structure, it represents deep social structures [2] [10]. Bachelord (1994) argued that personal factors such as intimacy, daydreams, imagination, and memories affect the establishment of a home [1].

II. Problem Formulation

Indeed, while shelter provides just place for sleep and eat, house, as a place for life spending additionally has to provide safety and functionality for routine chores. Home, as a symbol of owner's success, represents owner's ID and social status. So, these levels of residential space correspond to levels of Maslow's pyramid structure which can be simplified to three levels as physiological needs, safety and belonging needs and esteem and self-actualization needs.

The question raised is: if culture is the main determinant of people's housing preferences is it possible to identify a different housing preferences structure based on Maslow's pyramid for different cultural groups, for example, Czech, Turkish and Russian? It will be helpful in identifying operable definitions in architectural design and marketing strategy. Ozdemir (2013) used technique similar to one used by Israel (2003) for identifying housing preferences in Czech Republic, Turkey and Russia. Similarly she used homeowners' childhood memories picked up during in-depth interviews for identification of preferred characteristics of residential space for certain groups of respondents. As a result, she found core category with three subcategories of preferred characteristics for each group; these were Nature (Wood, Garden, Yellow) for Czech group, Cleanliness (Big House, Light-Well/White, Simple Furniture) for Turkish and Heat (Small House, Oven, Warm Colors) for Russian groups [11]. The author of this research is attempting to expand upon previous studies based on user-values - housing attribute relationship, into investigating the effects of Maslow's hierarchy of needs on customers' residential space attribute preferences and on intercultural marketing strategy for housing market.

III. Problem Solution

Table 1 shows levels of residential space with examples for three countries, related to market segments.

Three levels of residential space are useful for product segmentation strategy on housing market; moreover, it is already widely used by marketing specialists. Usually housing products are divided to standard and luxury categories that allow identifying consumer segments with different income levels and thus, preferences. The categories may differ across countries; for example, in Russia because of large stock of Soviet era poor quality block mass housing most of which may be considered as Shelter, there are different renovation styles for converting it into various categories of housing. Elite renovation housing is included to luxury category that may be considered as Home, Western-style and cosmetic renovation housing may be referred to House level, and rest of standard old mass housing with poor quality and functionality may be attributed to Shelter.

Czech housing stock also includes Panelaks block mass housing as Soviet era heritage, small housing consisting of just one room without any bathroom and/or kitchen is quite common and clearly may be classified as Shelter.

Shelter level of housing may be hardly found in Turkey, with exception of social housing such as homeless shelters and dormitories. The reason lays in historical Government policy and Housing Law. Historically, there was insufficiency of large-scale housing projects in Turkey. A key element in mass housing development, Mass Housing Law with Housing Development Fund, was effective just about a decade since its first adaptation in 1981 and till major economic and political challenges in 1993. Small constructors were more customers oriented with individual small-scale projects that allowed maintaining of traditional housing style. So, housing in Turkey may be divided into two categories, Standard and Luxury.

Relating Maslow's statement to housing market, as soon as needs for Shelter are gratified home users will aspire to go up to House level of cognitive needs and after it to the highest level of needs, that is Home. Thus, every level of residential space includes all lower levels as well. So, rich Russian customer beside of under floor heating system will still look for small rooms and well-insulated plastic windows in opposite to Czech who will still prefer wooden windows with plenty of fresh air and Turkish who will still look for white tiles and spacious rooms.

As it was mentioned above, Maslow's hierarchy of needs is useful for customers' segments definition and segmental marketing strategy development. Marketing strategy includes whole marketing mix or 4P: Product, Price, Place, and Promotion. Housing market has some unique features like average price for square meter of housing, which is among main economic indicators of certain region with exception for luxury housing. In Turkey, luxury housing differs from standard by location, size and materials used. Also prices are relatively low, Turkish housing is relatively big, the smallest

ISBN: 978-1-61804-255-2

one consists at least of two rooms. Luxury housing in Prague differs also mainly by location as the cheapest Panelaks are situated in certain areas, mainly in outskirts of the city, like Prague 21. In Russia average prices for new housing are about 13% lower than for secondary, it is because of new housing is being sold without any or with minimum finishing, so it means, the buyer will also pay for design and reconstruction.

Place/Distribution strategies tend to be exclusive through one real estate agency or even directly from owner to customer. Customers look for housing at the certain area, often quite small, so they prefer to contact local agents or direct owners who are able to give all specific details and have an access to the housing. It is common for Russian real estate agencies to have selling contracts, signed by house owners, with a requirement of exclusivity.

Promotion of housing product by itself in most cases consists of advertising as it is being distributed through exclusive real estate agent that is already well known in target area; other elements of Promotion Mix refer to the agent, not to the housing product. Advertisements in most cases are placed in Internet; new developments are often advertised at the street banners and on TV. Dwelling (Shelter) level housing product already has an advantage of lower price, so advertising is not as important as for House and Home level products. Working creative promotion advertising strategy must have well memorable short point; it may be a logo or catchy, snappy short tagline that grabs the customer's attention and makes her or him to read or listen more in order to get the joke. It should appeal to exact target audience considering its needs and expectations. Here, there is a wide space for application of Maslow's pyramid and cultural categories found in previous studies and related to it. Core categories are useful for short catchy taglines and logos. Categories may be useful for further scene development. It is important to appeal to right customers segment, for example, while Dwelling level customers segment consists mostly of young singles, that like humor and trendiness, House and Home segment customers value more sophisticated humor and quality and they will hardly be impressed by simple advertisements for youths. While House level product advertisement should either point practice and convenience in use of rooms and appliances, Home advertisements emphasizing high quality should show an image created by product in others' minds. The main images created by advertisement in customers' minds should be Freedom and Adventure for Shelter, Family and Friends for House and Symbol of Luxury and Success for Home levels.

IV. Conclusion

As it is seen from the examples above, Maslow's hierarchy of needs with culture in its basis may be useful for improving marketing strategy and thus sales for different segments of market. Examples for housing market clearly show differences in perception of ideal housing and expectations of different segments of customers in different cultures. Also upper level of needs includes lower levels; segments of customers with different needs within one culture differ significantly by price and place of distribution. Product and promotion for different segments have common attributes but different expectations within one culture, applying this knowledge, however, will result in optimal product and advertisement development with lower costs and possibility to sell with the highest possible for the segment price. Knowledge of cultural categories and needs of different segments in different cultures is beneficial for international companies that are common in multicultural EU. Often constructors spend money for unnecessary from cultural needs and expectations point of view elements in the house, that increases costs and decreases profits. For example, one Turkish luxury-housing constructor used expensive solid wood floor in their luxury apartments in Istanbul. However, wooden floor is an attribute, important for Czech customers, and is not a decisive factor for Turkish. Cheaper tile floor was going to have even more positive effect on Turkish customers as it shows the place more spacious and clean (Pic 1).

The constructor could save about 1000 Euros if the floor in this single room was tiled. Total saving for each 4 rooms apartment was going to be at least 2500 Euros and 120.000 Euros for a building of 50 apartments.

Decreasing costs and increasing profits is one of the main purposes of company management and marketing. Using Maslow's hierarchy of needs and related cultural categories in Marketing Mix allows developing successful and competitive advantage gaining marketing strategy for company in intercultural market.

References

[1] BACHELARD. (1994). The poetics of space. Boston: Beacon Press .

[2] BANHAM. (2007). A home is not a house. In Miller, Housing and dwelling: Prespective on modern domestic architecture (pp. 54-61). New York:: Routledge.

[3] HEPPNER. (n.d.). 35 things you will want in your house. Retrieved 04 20, 2014, from Business Inside: http://news.distractify.com/culture/dream-house/

[4] ISRAEL. (2003). Some place like home: Using design psychology to create ideal place. New York: John Wiley & Sons.

[5] JUSAN. (2010). Renovation for personalization: A development arm for sustainable housing. Skudai: UTM press.

[6] MACCRAY, & DAY. (1977). Housing related values, aspirations, satisfactions as indicators of housing needs. Family and consumer sciences research journal , 5 (4), 244-254.

[7] MASLOW. (1970). Motivation and personality. New York: Harper and Row .

[8] NORBERG-SCHULZ. (1985). The concept of dwelling: On the way to figurative dwelling. Milano: New york: Rizzoli International.

[9] OLIVER. (2006). Built to meet needs: Cultural issues in vernacular architecture. Italy: Architectural press.

[10] OLIVER. (2006a). The cultural context of shelter provision. In Oliver, Built to meet needs: Cultural issues in vernacular architecture (pp. 185-197). Italy: Architectural press.

[11] OZDEMIR. (2013). Tell me your ethnicity and I will tell you what you are: Culture as a key factor of creativity in business. International Journal of Knowledge, Innovation & Entrepreneurship , 1 (1-2), 185-198 .

[12] RAPOPORT. (2000). Theory, culture and housing. Housing, theory and society , 17, 145-165 .

[13] ZAVEI, & JUSAN. (2012). Exploring Housing Attributes Selection based on Maslow's Hierarchy of Needs . Procedia - Social and Behavioral Sciences . 42, pp. 311 – 319. Malaysia: Elsevier.

Computational modeling and multi-agent-based simulation framework for product branding

Qingqi Long [1], Shuliang Li [2,3]

[1] School of Information, Zhejiang University of Finance & Economics, Hangzhou, Zhejiang, 310018, China
longqingqi1116@163.com
[2] Westminster Business School, University of Westminster, London, NW1 5LS, United Kingdom
lish@westminster.ac.uk
[3] School of Economics & Management, Southwest Jiaotong University, Chengdu, Sichuan, 610031, China
simonxnjd@gmail.com

***Abstract*—Aiming to deal with the complexity and dynamics of the product branding problem and investigate its evolution process, this paper proposes a framework for evolutionary product branding and emergence on the basis of computational modeling, and software agents' behaviors and interactions. In this framework, relevant conceptual, mathematical and computational models are formulated and explained. Two categories of agents with four kinds of basic behaviors and three types of interactions are defined and specified to support the emergence of product brands. Agents' behaviors and interactions are described in detail. In addition, a multi-agent-based evolution simulation paradigm for the product brand life cycle is presented by the authors. Our evolution model provides a foundation for analyzing the emergence and evolution of product brands and supporting decision-making for product branding management in the digital age.**

Keywords- Product branding; computational modeling; evolution modeling for product brands; multi-agent system; simulation

I. INTRODUCTION

Product branding is a hot research topic in the field of marketing. The related literature can be classified into qualitative research [1] and quantitative research [2, 3]. The qualitative research focuses on the concept definitions, theoretical analysis, trend prediction, influence factors, and decision-making issues for product branding. The quantitative research tends to use associated methods to study the mechanisms of product brand formation, development, maturity, and decline and provide valuable information for branding decisions.

The product brand has its life cycle, generally including four periods of formation, development, maturity, and decline. The product branding should be treated as a dynamic process evolving over time. Effective quantitative methods need to be employed to cope with the dynamics. According to the literature, the product branding process is also complex [4]. Its complexity is emerged by micro-level entities' behaviors and interactions. A product branding system is composed of multiple heterogeneous entities that have their individual attitudes and behaviors, and pursue their own maximum benefits during their interactions. The system's macro-level phenomena are emerged by these entities' behaviors and interactions. Much of the current literature emphasizes the mathematical models in the quantitative research of product branding. It has a deficiency in dealing with the complexity, dynamics, emergence, and evolution of product branding. Simulation is also a quantitative tool and has been increasingly used in economic and social research. It not only has the advantages of the traditional mathematical and logical models, but also has a more important capability for complex system modeling and analysis. As such, the simulation technique can be utilized to explore the occurrences and evolution of product branding system. Since the product brand is emerged by micro-level entities' behaviors and interactions, multi-agent software system is an ideal choice. Intelligent software gent can be smart and active, and can make decisions autonomously based on self-perception of its environments and interactions with other agents. A multi-agent system consisting of multiple agents, combined with complex adaptive system theory (CAS) [9], can be developed to represent a product branding community. This is a complex system research methodology that is powerful in modeling and analyzing micro-level agent interactions and macro-level emergence. It has incomparable strengths in tackling unstructured complex problems that are difficult to be solved by pure mathematical models.

This paper combines multi-agent-based system, simulation technique, with CAS to establish a new hybrid evolution framework for product branding. A conceptual model of product brand emergence on the basis of agents' behaviors and interactions is given in Section II. Systematic and computational modeling work is reported in Section III. Conclusions and further work are provided in Section IV.

II. CONCEPTUAL MODELING OF PRODUCT BRAND EMERGENCE ON THE BASIS OF AGENTS' BEHAVIORS AND INTERACTIONS

Product branding can be treated as a complex emergence phenomenon. This paper considers the product brand as the emergence of behaviors and interactions of firms, customers and wider community. We propose a conceptual model of product brand emergence, as shown in Figure 1. This model makes use of autonomous decision-making capabilities of agents and interactive features of multi-agent systems to represent the behaviors and interaction of entities in the product branding community for the purposes of analyzing emergence and evolution. This paper simplifies the product branding community as a system consisting of two types of important entities of firms and customers. The behaviors of firm agents are defined as product innovation behavior, marketing behavior, and coordination behaviors with other firm agents. These behaviors directly affect the formation and development of firms' product brands. Customer agents make their purchase decisions based on their maximum interests. Their decisions are significantly influenced by product quality, price, advertisement, and word of mouth in social media and other contexts. The conceptual model specifies three types of interactions: Interactions amongst firm agents, interactions amongst customer agents, and interactions between firm agents and customer agents. The product branding can be considered as the outcome or occurrences of these agents' behaviors and interactions. Other factors affecting the product brand evolution are treated as external variables embedded in the conceptual model. In this way, the conceptual model is actually a dynamic evolution system.

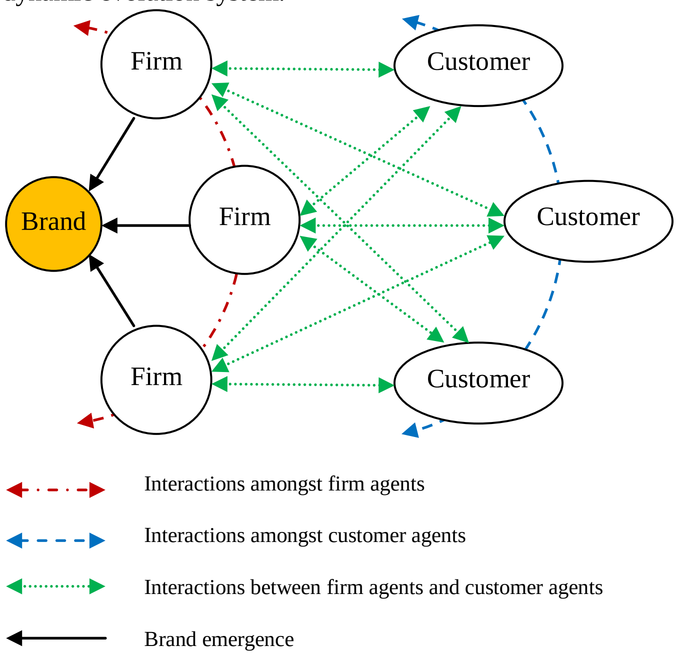


Figure 1. Product brand emergence based upon agents' behaviors and interactions

III. System and Computational Modeling

In this section, a systematic and computational modeling framework for simulating and analyzing the behaviors and interactions of different kinds of agents as well as their influences on the product branding evolution is proposed and discussed.

A. *Product Brand Modeling*

The product brand has its life cycle with four periods: formation, development, maturity, and decline. The degrees of product branding at different periods vary and thus are not the same. In this paper, the degree of product branding is defined as a function of market share rate and coverage rate of a product brand.

$$Degree_{brand_{j,k,t}} = \alpha \frac{Sale_{brand_{j,k,t}}}{\sum_{l=1}^{n} Sale_{brand_{l,k,t}}} + (1-\alpha)\frac{Customer_{brand_{j,k,t}}}{\sum_{l=1}^{n} Customer_{brand_{l,k,t}}}$$

$Degree_{brand_{j,k,t}}$ is the branding degree of product brand k of firm j at the evolution period t; $Sale_{brand_{j,k,t}}$ is the sale volume of product brand k of firm j at the evolution period t; $Customer_{brand_{j,k,t}}$ is the customer number of product brand k of firm j at the evolution period t; $\sum_{l=1}^{n} Sale_{brand_{l,k,t}}$ and $\sum_{l=1}^{n} Customer_{brand_{l,k,t}}$ are respectively the total sale and total customer number of product brand k of a specific market at the evolution period t; n denotes the total number of firms considered; α is a coefficient representing the relative importance of market share rate and coverage rate of the product brand.

B. *Agents' behaviors modeling*

The branding degree mainly depends on firms' strategies, micro-level behaviors and the interactive relationships with other firms, competitors and their customers. According to complex system theory, firms' behaviors and interactions emerge their product brands. In this section, the behaviors of firms and customers will be discussed.

1) *Firm agents' behaviors*

In order to develop and build their product brands, firms need to innovate, do marketing, and coordinate with other related firms effectively. Therefore, this paper defines three types of basic behaviors which are product innovation behavior for sustainable development, marketing behavior for customer attraction, and coordination behaviors with other firms for cooperation.

Product innovation behavior: This behavior drives and contributes to the formation and development of a product brand. Product innovation is closely associated with current innovation knowledge, capital investment, and technology/labor inputs. Innovation is not always successful. In this paper, we assume that the probability of successful product innovation at each evolution period is P. In essence, product innovation can be considered as knowledge creation and production. Thus, the model for knowledge production can be employed. On the basis of the knowledge production function given in [5], we define the growth of innovation knowledge of product brand k of firm j after one-time innovation activity at the evolution period t as follows:

$$\Delta IK_{j,k,t} = \delta_{j,k} K_{j,k,t}^{\beta} L_{j,k,t}^{\lambda} IK_{j,k,t}^{\varphi}$$

Within this formula, $IK_{j,k,t}$ is the current innovation knowledge of product brand k of firm j at the evolution period t; K and L are dynamic variables, respectively representing capital investment and technology/labor inputs for product innovation. β and λ respectively stand for the efficiencies of capital investment and technology/labor inputs in knowledge production process. φ describes the spillover efficiency and effect of knowledge production based on the innovation knowledge at the previous period. If $\varphi > 0$, it is called positive effect. If $\varphi < 0$, it is called drag effect. δ is a comprehensive factor except for such factors as capital, technology, labor, and previous innovation knowledge. Successful innovation will increase agents' innovation knowledge which will in turn improve product quality and reduce product price. Hence, the product quality and price are affected by the amount of firm's innovation knowledge. The quality is proportional to the amount of knowledge, while price is inversely proportional.

Marketing behavior: In order to sell their products, firms tend to use several ways to attract their customers. The product quality marketing, price marketing, and advertising campaigns are three main kinds of marketing behaviors. These behaviors can influence customers' purchase decisions. The quality is affected by product innovation. The price can be fluctuating with a certain proportion to the basic price determined by product innovation, and accounting management. The advertisement is fully determined by its investment. Therefore, high quality, low price and big advertisement investment of a product brand may lead to more attraction to customers and may create more customer awareness.

Coordination behavior with other firms: Many firms tend to cooperate with their partners or collaborators for high performances, such as cost reduction, differentiation, quality, and image. The coordination behaviors with other firms include: quality coordination on the basis of product cooperation innovation; price coordination, advertisement coordination, and brand union coordination, on the basis of profit and benefit distribution mechanisms. The effect of coordination behaviors influences the purchase decisions of customers. Quality coordination behavior can be referred to the cooperative innovation model in the literature [6]. Price coordination, advertisement coordination, brand union coordination are determined by benefits distribution mechanisms.

2) Customer agents' behavior

Customers are sensitive to product quality, price, advertisement, and word of mouth from other customers when they are making purchase decisions. Their purchase decisions are normally based on their maximum benefits and are affected by these factors. Following the literature [7], this paper defines the benefit function of customer i to the product brand k of firm j at the evolution period t as follows:

$$V_{i,j,k,t} = S_{iQ_{j,k,t},t} Q_{j,k,t} + S_{iP_{j,k,t},t} P_{j,k,t} + S_{iA_{j,k,t},t} A_{j,k,t} + S_{iM_{j,k,t},t} M_{j,k,t}$$

In the formula, $S_{iQ_{j,k,t},t}$ is the sensitive degree of customer i to the product quality of the product brand k of firm j at the evolution period t; $Q_{j,k,t}$ is the product quality of the product brand k of firm j at the evolution period t; $S_{iP_{j,k,t},t}$ is the sensitive degree of customer i to the product price of the product brand k of firm j at the evolution period t; $P_{j,k,t}$ is the product price of the product brand k of firm j at the evolution period t; $S_{iA_{j,k,t},t}$ is the sensitive degree of customer i to the product advertisement campaign of the product brand k of firm j at the evolution period t; $A_{j,k,t}$ is the advertisement investment of the product brand k of firm j at the evolution period t; $S_{iM_{j,k,t},t}$ is the sensitive degree of customer i to the word of mouth of the product brand k of firm j at the evolution period t; $M_{j,k,t}$ is the word of mouth [10] or mentions in dynamic social media environments or other offline contexts with regard to the product brand k of firm j at the evolution period t. Assuming that the expect benefit of customer i to the product brand k is $V_{i,k}^{E}$. If $V_{i,j,k,t} \geq V_{i,k}^{E}$, the customer will purchase the product of the brand k of the firm which can deliver the maximum benefit to the customer; if $V_{i,j,k,t} < V_{i,k}^{E}$, the customer will not buy the product of the brand k of firm j.

C. Agents' interactions modeling

1) Interaction amongst firm agents

Modeling the interactions among firm agents aims to coordinate each other. The ways for coordination include quality coordination, price coordination, advertisement coordination, and brand union coordination. Relevant coordination behaviors are conducted by firms only when their benefits obtained from the coordination are higher and better than their expected values. The effect and consequences of interactions between firm agents influences the purchase decisions of customers.

2) Interactions between firm and customer agents

The contents of interactions between firm agents and customer agents include product quality, price, advertisement, advertising campaign, and the word of mouth. High product quality will improve the customers' preferences to a product brand. Low price will improve the customers' choices for a product brand. Large advertisement investment and intense advertising campaign will enable customers know more about a product brand, help attract more potential customers, and build up customer loyalty. Good interactions between firm agents and customer agents may lead to the favorable purchase decisions by customers.

3) Interaction amongst customer agents

The content of interactions among customer agents includes buzz, mentions, the word of mouth for a product brand online and offline. Customers will be greatly affected by these, which can be either positive or negative. The positive side will increase customers' trust, loyalty and confidence to a product brand. The negative mentions will lead to bad influence to customers' purchase decisions. Both affect customers' purchase behaviors. A model of word of mouth for interaction between customer agents can be found in literature [8].

D. System evolution solution

Micro-level agents' behaviors and interactions emerge the macro-level phenomena, such as customers' likes and loyalty, and image of a product brand. In the life cycle of a product brand, the evolution process can be simulated by the proposed conceptual and computational framework, combined with Holland's CAS theory [9] and intelligent software agent implementation.

The interactions amongst relevant entities or agents are non-linear. Some buzz, mentions or words of mouth may exponentially cause significant emergence to arise from online or offline communities. Some occurrences may help improve a product name. Some may damage a brand negatively. The brand, the firm, competing brand, competitors, customers, communities interact with each other. Patterns may appear from these interactions. At the macro level, emergence such as big name, reputation, popularity and good customer loyalty may emerge [10].

Data can be collected from simulation experiments, and analysis can be performed to support product branding management.

IV. Conclusions and Further Work

This paper has been sought to provide a quantitative framework for modeling and simulating the evolution process of product branding. In this paper, a conceptual, mathematical and computational model for product branding has been proposed. A multi-agent-based simulation framework combined with CAS theory and algorithms have also been discussed.

Further research work is being done to create and validate a multi-agent-based simulation and CAS system for product branding analysis. The target system and associated methods will be tested and evaluated using real-world cases.

Dealing with the product branding problem requires a hybrid approach that integrates the benefits and powers of human experience, managerial judgment, mathematical and logical modeling, computer simulation, intelligent software agent technology, CAS algorithms, and expert systems[11, 12]. The specific strengths of diverse decision support and artificial intelligence methods and techniques will be utilized to match and fit the particular facets or properties of the problem, the thus will provide enhanced support and effective solution [11,12]. Relevant research work of this project is being undertaken by the authors to implement this hybrid approach.

Acknowledgements

This work was supported by the Humanities and Social Science Youth Foundation of the Ministry of Education of the Republic of China (No. 14YJC630090), Zhejiang Provincial Natural Science Foundation of China (No. LQ13G010003), Zhejiang Philosophy and Social Science Planning Project of China (No. 13NDJC039YB), Sichuan 100-Talent Scheme (bai ren ji hua) grant, and the University of Westminster staff research allowances.

References

[1] P.Y. Lam, A. Chan, H. Gopaoco, K. Oh, T.H. So. Dual branding strategy for a successful new product launch in China. Business Horizons, 2013, 56 (5): 583-589.

[2] U. Tuskej, U. Golob, K. Podnar. The role of consumer–brand identification in building brand relationships. Journal of Business Research, 2013, 66 (1): 53-59.

[3] L. Lockshin, J.A. Wade, F. d'Hauteville, J.P. Perrouty. Using simulations from discrete choice experiments to measure consumer sensitivity to brand, region, price, and awards in wine choice. Food Quality and Preference, 2006, 17 (3&4): 166-178.

[4] R. Jarventie-Thesleff, J. Moisander, P.M. Laine. Organizational dynamics and complexities of corporate brand building-A practice perspective. Scandinavian Journal of Management, 2011, 27 (2): 196-204.

[5] C. Yan, M. Zhou, L. Gong. Knowledge production, innovation and the return to R&D investment. China Economic Quarterly, 2010, 9 (3): 1051-1070. (In Chinese)

[6] Q. Long, S. Li. A multi-agent-based evolution model of innovation networks in dynamic environments. In: Proceedings of Mathematics and Computers in Sciences and Industry (MCSI 2014), 13th-15th September, 2014, Varna, Black Sea, Bulgaria. In press.

[7] T. Zhang, D. Zhang. Agent-based simulation of consumer purchase decision-making and the decoy effect. Journal of Business Research, 2007, 60 (8): 912-922.

[8] R. East, K. Hammond, W. Lomax. Measuring the impact of positive and negative word of mouth on brand purchase probability. International Journal of Research in Marketing, 2008, 25 (3): 215-224.

[9] J. H. Holland. Studying complex adaptive systems, Journal of Systems Science and Complexity, 2006, 19(1), pp.1-8.

[10] S. Li, J. Z. Li. Web and social media dynamics, and evolutionary and adaptive branding: theories and a hybrid intelligent model. In: Proceedings of the 13th international conference on artificial intelligence, knowledge engineering and data bases, 15-17th May 2014, Gdansk, Poland. Advances in Neural Networks, Fuzzy Systems and Artificial Intelligence . WSEAS, 106 -111. ISBN 9789604743797

[11] S. Li. The development of a hybrid intelligent system for developing marketing strategy, Decision Support Systems, 2000, 27(4), pp. 395-409.

[12] S. Li, J. Z. Li, Li. AgentsInternational: integration of multiple agents, simulation, knowledge bases and fuzzy logic for international marketing decision making, Expert Systems with Applications, 2010, 37(3), pp. 2580-2587, 2010.

Considerations related to the exemption from liability in case of occurrence of a force majeure event or of unforeseeable circumstances

DIANA GORUN

Abstract **-**The liability of the debtor for the damages caused by the unfulfilled obligation is exempted when the prejudice is determined by the force majeure or the unforeseeable circumstances.

Keywords **-** Liability,force majeure, unforeseeable circumstances.

I. Introduction

The force majeure and the unforeseeable circumstances are defined by article 1351 of the new Romanian Civil Code as follows:

Paragraph (1) If the law does not provide otherwise or the parties do not agree on the contrary, the liability is exempted when the prejudice is determined by the force majeure or the unforeseeable circumstances.

Paragraph (2) The force majeure is any external event, unpredictable, absolutely invincible and inevitable.

Paragraph (3) The unforeseeable circumstances is represented by the event that cannot be foreseen or prevent by the person that would be held liable if the event did not occur.

Paragraph (4) If, in compliance with the law, the debtor is exempted from its contracting liability for any unforeseeable circumstances, it is, at the same time, exempted in the event of force majeure.

In the previous Romanian Civil Code, in force until 01.10.2011, these two denominations were used together as synonyms; however, we can find that the current Civil Code defines them separately in article 1351 paragraphs (2) and (3).

Related to this different approach of the two notions, the issue raised in that to know that if the two denominations take into account a single exonerating cause of civil liability or each of them are related to a different notion, with its own significance and content. It is natural that, while the law-maker regulated separately these two notions, they are different and they must be analyzed separately.

II. Problem formulation

The legislature has classified in a different way the force majeure and the unforeseeable circumstances as causes of liability exemption.

2.1. Expressing the law issue

According to article 1351 paragraphs (1) and (4), although both the force majeure and the unforeseeable circumstances are causes of liability exemption, the two legal notions are different and have their own effects.

2.2. The difference between the force majeure and the unforeseeable circumstances

Bearing in mind that, in accordance with the provisions of article 1351 paragraph (2) Civil Code, “the force majeure is any external event, unpredictable, absolutely invincible and inevitable”, the occurrence of a force majeure event excludes in full liability, if this was the exclusive cause of the damage.

The unforeseeable circumstances are defined, in accordance with paragraph (3) of the same article, as an event that cannot be foreseen or prevent by the person that would be held liable if the event did not occur. That means that in this case the civil contracting liability can be excluded.

Unlike the unforeseeable circumstances, the force majeure has always an external character and it is an unpredictable, absolutely invincible and inevitable event.

The causes of force majeure are the natural incontrollable and unpredictable events (earthquake, eruption of volcanos, storm, tsunami, flood, fire, typhoon, bird flu, any other catastrophe, war, terrorist attack, coup d'état, etc.)

In order to be retained as a cause of force majeure, it is not enough for the event to be external as compared to the will of the parties and unpredictable, but it should be nevertheless impossible to be prevented and overcome by the parties. Force majeure requires an objective impossibility character. This provision impossibility of an event can be appreciated by reference to the prudent person depositing all the care for his work [1].

We should bear in mind that in case of the notion related to the unforeseeable circumstances, it is not the external feature of the event that occurs. It comprises natural phenomena, if they do not have an extraordinary feature, absolutely unpredictable, invincible and inevitable, therefore they cannot be considered within the scope of the force majeure; the events and internal phenomena, meaning that those events that are originated or are produced in the scope of activity of the person held liable; the anonymous causes and non-culpable facts.

Therefore, in order for the liability exemption to occur, all the circumstances that prevent the performance of the contract must be independent of the parties will and to be incontrollable. It is difficult to consider generally if a certain event is or not a force majeure event and if it exempts or not the debtor in case the undertook obligations are not fulfilled.

In the judicial practice, the events of force majeure were considered to be natural catastrophes (earthquakes, droughts, storms, floods, wars, spontaneous strikes, embargo etc.). Such events cannot be considered absolutely as force majeure, however, they must be taken into consideration on each case, assessing if they fulfill or not the conditions of such event which can exonerate the debtor from its liability [2].

For example, it was considered that the flood or the earthquake cannot be considered a case of force majeure in those territories or geographical areas where such catastrophes are a normal and habitual situation. In this regard, the legal practice indicated that the frequent landslides, torrential rains, frost are not unforeseeable events, as they cannot be considered as cases of force majeure [3].

Related to the cause of the force majeure agreed by contract, the parties can agree by a deed that certain event to be assimilated to the force majeure.

However, we have to specify that including in the contracting liability case, proofing a case of force majeure does not result in the liability exemption under the following circumstances:

- the debtor was put in delay to execute the obligations taken (therefore it did not fulfilled its contracting obligations in due time), and the event of force majeure occurred after that moment, therefore the debtor will have the obligation to assume its liability as, if it would have executed its obligations in due time, the cause of force majeure would have occurred after the performance [4];
- when by a contractual convention/clause, the debtor expressly assumed its liability.

The conclusion that can be drawn related to the difference between the force majeure and the unforeseeable circumstances must take into account the provisions of article 1352 of Civil Code, according to which "The fact of the victim in itself and the fact of the third party exempts the liability even if they do not have the characteristics of the force majeure, only those of the unforeseeable circumstances, however only in the case that, according to the law and agreement of the parties, the liability is exempted". The conclusion is that the force majeure always and entirely excludes the liability, but not any unforeseeable circumstances due to the exemption of liability.

2.3. Case under discussion

The plaintiff trading company SC B called into justice the trading company SC A bearing in mind that on 20.06.2012, the plaintiff SC B as the Purchaser and the defendant SC A as the Seller signed the purchase agreement for Romanian black oil sunflower seeds, in bulk for the 2012 crop, amounted 300 metric tonnes for the price of $500 per metric tonne, following the delivery to be made during the interval 10.08.2012-30.09.2012. According to the contract, the Seller undertook the obligation to deliver the respective quantity of products, and no provision was made for the Purchaser to make any advance payments.

By the writ of summons submitted to the Buzau Court of Law, the plaintiff company B requested the obligation of the defendant company A to pay the amount of $44,100 as damages representing the amount of the damaged occurred for SC B following the failure of performing the contractual obligations by SC A, by its own fault.

On 30.07.2012, SC A submitted a notification by fax informing SC B that an event occurred, classified as force majeure and which made the selling company impossible to deliver the products on the term established. In this case, due to the aggressive and extended drought, the oilseed sunflower production was 99% affected, which lead to the impossibility to deliver the products. SC A also submitted a deed called "force majeure certificate", issued by the Giurgiu County Chamber of Commerce, Industry and Agriculture, where SC A is headquartered, which certifies that in July 2012, an aggressive and extended drought occurred, affecting the crops of the territory of Giurgiu County.

In reasoning its writ of summons, the plaintiff mentioned the fact that as sunflower oil producer, it had to observe a number of sunflower oil delivery orders, indicating that it had to find other suppliers of sunflower seeds to cover the lack of the 300 metric tons which were not delivered by company A.

In order to avoid the occurrence of further damage, SC B concluded the purchase agreement dated 19.09.2012 with SC X for the quantity of 2000 metric tonnes of oil sunflower seeds against the price of $665/metric tonne.

The plaintiff considered that the difference between the price paid by the third party company and the price agreed is the damage occurred by the fact of the defendant company, consisting in failure to fulfill the product delivery obligation.

III. Problem solution

In our opinion, the action of the plaintiff is not grounded and it has to be rejected because of the following reasons:

3.1. Specifications related to the classification of the incident contract in question, called "purchase agreement"

As a matter of fact we are talking about a sale-purchase agreement subjected to a sale of future merchandise in accordance with article 1658 paragraph (1) of Civil Code – sale of a future crop – meaning merchandise from a limited category (crop of year 2012, not 2011 or 2010, included in the own production made by SC A).

We support this affirmations as when the contract was signed – June – the oil sunflower seeds crop afferent for year 2012 was in progress, therefore the contracted merchandise at the time did not actually exist, following to grow into the future, when it reached its maturity and being harvested.

ISBN: 978-1-61804-255-2

Under such circumstances, there is no doubt that the object of the contract was a future good. Although the parties classified the contract as a sale-purchase agreement, in fact its legal classification is production agreement, as SC A was not an intermediary which only sells the respective products, but a producer.

3.2. Inapplicability of the principle *genera non pereunt* and the incidence for the case of article 1658 paragraph 2 of Civil Code

The plaintiff claimed that for the cause in question the principle *genera non pereunt* can be applied, according to which if the products subjected to the agreement ceased to exist, but they are products of type, *res genera*, meaning they can be replaced and the debtor has the obligation to fulfill its liability, by replacing and delivering of certain products of the same type [5].

This principle was to be implemented absolutely as compared to the provisions of the previous Civil Code, however the Romanian law-maker introduced an application of this principle by the new Civil Code, which provides in article 1658 paragraph (2) that "when the product or, as the case may be, the limited type is not achieved, the contract shall bear no effects ".

Bearing in mind that the new Civil Code refers to the notion of limited type products, however without specifying any definition or characterization of such products, we consider that a short definition of the two notions is needed: goods of a certain type and goods of limited type.

The goods of a certain type or series products belong to a certain category (e.g. grain, alcohol, clothing) without any individualization of any kind within the batch they are part of, being considered interchangeable/exchangeable, so that in case of sale of goods of a certain type, the seller has the possibility to deliver the purchaser any of them, which is considered a valid fulfillment of contracting obligation. Therefore, this is how we explain the fact that the cessation of good of certain type cannot occur, having a case of *genera non pereunt*. According to some authors, even if the certain type goods cannot dissaper, the limited type goods can [6],[7].

However, if when the sale-purchase agreement is concluded for good of a certain type, *genus limitatum*, they are individualized, meaning from generic/determinable (e.g. grain), the good become determinated/individualized (e.g. wheat, corn, sunflower in a certain batch/a determined crop) then they are classified as sale of limited type goods, meaning the sale of goods of certain type, but limited to those in a well determined place and which are part of a certain batch, in the case being the oil sunflower seeds form the crop produced by SC A.

In case of goods of a certain type, as a matter of fact, the principle *genera non pereunt* is incident; however, this principle cannot be applied to the goods in a limited type. For example, if 200 tons of corn is sold, without indicating their provenience, and the corn the seller considered meant to fulfill the obligation ceased to exist, it is still a debtor, as it can at any time procure other corn instead from another place.

We are facing a whole different situation when we are talking about the sale of a limited type product.

Therefore, if the seller, for example, sells 200 tons of corn from a crop in a certain year, and the corn crop is lost due to a case of force majeure, the seller cannot be held liable related to the delivery, as we are not talking about selling 200 tons of corn generally, but 200 tons of corn limited as type, in the case being the oil sunflower seeds in the crop of year 2012 of producer SC A.

Therefore, we are facing the incidence of provisions of article 1658 paragraph (2) second thesis of Civil Code, as the good of a limited certain type contracted was not achieved due to a force majeure cause, respectively the draught, thus occurring the liability exemption of the seller, which cannot be held liable for the failure to achieve the goods, because the contract has no legal effects.

3.3. The existence of the force majeure and failure to fulfill the contracting obligations

SC A requested the court to acknowledge that it was facing an event of force majeure which resulted in the impossibility to observe its liability.

Draught is considered as a real cause of force majeure, as in this regard, the Giurgiu County Chamber of Commerce, Industry and Agriculture issued a certificate. Therefore, draught classified as force majeure cause leads to the exemption of liability in case the parties failed to fulfill their obligations.

Against the claims of the plaintiff, meaning that this certificate of force majeure is not considered a true evidence, we indicate that such certificate is issued only based on documents that are issued by the qualified bodies related to the existence and effects of the event invoked, its localization, moment of occurrence and termination.

It is well-known that in 2012 in Romania the lack of precipitations and naturally of river coursers had serious effects for the whole economy of the country, thousands of hectares of agricultural land being affected by the serious draught, the corps of inland producer being, in most of their part, seriously affected.

This situation of force majeure was acknowledged nationally by Govern Decisions by which in agriculture a state of natural disasters were established, determined by the draught all the counties of the country were facing in 2012.

Anyway, according to article 28 paragraph (2) letter i of Law 335/2007, the Chambers of Commerce and Industry approve the existence of force majeure and their effects on the performance of commercial obligations by the request of Romanian companies, based on documentation.

At the same time, on European level measures were taken, the European Commission giving compensations to Romania, as aid to cover the costs of the damages produced by the draught and woods fires from summer of year 2012.

We consider that for the case being the characteristic features of the force majeure are fulfilled:

- the event is not related to the action/lack of action of SC A;
- the severity of the draught was unforeseeable as SC A had no possibility to intervene to prevent or eliminate the hazard of its occurrence;
- the draught from summer of 2012 was absolutely invincible and inevitable, as it could not be avoided.

It is true that, in theory, there is the possibility of irrigating the areas harvested with oil sunflowers, however, for the case being, the area where the harvested surface is located there are no irrigation works in place, which put the company A under the impossibility to irrigate the harvest. We considered that this issue, of the lack of existence, or, as the case being, the impossibility to using the irrigation systems is a national issue, which, in the years to follow, it must be remedied by the authorities, as it is very likely that such phenomena of excessive draught to produce further in Romania, knowing that this country has extreme seasons, very hot summers and very cold winters.

Although the plaintiff claims that SC A must be liable for the damage caused, we consider that the sanction of obligating the company SC A to pay compensation can occur only if the obligation was not fulfilled culpably, which is not the case for our situation.

In this regard the provisions of article 1350 of Romanian Civil Code are specified: “Any person must fulfill its contracting obligations. When, **without any justification**, it does not fulfill its obligations, it is liable for the damage caused to the other party and has the obligation to repair this damage, under the conditions of the law.".

From the interpretation *per a contrario* of this law text, it results that the liability cannot be triggered in case that the non-compliance of the obligation has a justification.

The plaintiff claims that on 19.09.2012, following the non-fulfillment of the obligation by the defendant of the contracting obligations, it was put under the situation to purchase a quantity of 2000 metric tonnes of oil sunflower seeds against the price of $165/metric ton higher than the price agreed at first, to cover the quantity of 300 metric tonnes which were not delivered by our company. Although the defendant submitted for the case deeds indicating that it purchased oil sunflower seeds from other sellers, these contracts are concluded with producers being located in other counties of the country – for the case being Constanta County – not with producers from Giurgiu County, where the crops were almost totally compromised by the draught.

We consider that for the case being the proof of a cert damage cannot be bought, therefore, the conditions of triggering the contracting civil liabiliy are not fulfilled.

Related to the conditions of existence of a damage, it also brings into discussions the condition that this damage has to be sure, meaning sure to exist and to have the possibility of assessment. For the case being, the damage invoked by the plaintiff is not sure, because we cannot affirm that the quantity taken from other producers was bought to replace he quantity that was not delivered. And this is concluded by taking into consideration the difference between the quantitiy of 300 metric tones. Therefore, this condition is not fulfilled.

Related to the fault of the party, although in terms of contracting liability it is presumed, for the case being the presumption of not confirmed, proving the contrary, namely there is no fault of the defendant in fulfilling its contractual obligations.

All such issues have been acknowledged by the court of law, which rejected the action submitted by SC B, reasoning that in the case being, the force majeure case occurred which exonerated the company from its liability [8].

IV. Conclusion

Depending on the situation, some facts can be established as having the effect of exemption from contracting liability. As an example, these facts consist in the circumstances that are not entirely unpredictable, nor totally invincible, but can be real obstacles to fulfill the obligations arising from the contract.

Such a view demands tolerance for the classic point of wiev regarding force majeure. This theory is explained by the fact that in the new circumstances it becomes impossible to fulfill the contractual obligations on reasonable and normal terms [9].

As a conclusion, we consider that the contracting parties must protect themselves by including into their contracts certain provisions that should include the details related to the cases of force majeure and the steps to be taken into account of the parties under such circumstances (immediate notification, adopting certain emergency measures to limit the losses, calling the authorities to confirm the case of force majeure, etc.).

References

[1] D.-E. Sîngeorzan, *Contractual liability in civil and contractual law*, Publishing House Hamangiu, Bucharest, 2009, p. 223-224.

[2] Court of Highest Instance, Civil Division, decision no. 1096/1978, in Romanian Law Magazine no. 1/1979, p. 55.

[3] Court of Highest Instance, Civil Division, decision no. 1860/1986, in Romanian Law Magazine no. 6/1987, p. 70.

[4] V. Terzea, *New Civil Code*, Publishing House Juridical Universe, Bucharest, 2014, p. 334.

[5] F. Baias, E. Chelaru, R. Constantinovici I. Macovei, *New Civil Code, Articles Comments*, Publishing House C.H. Beck, Bucharest, p.589-590.

[6] F. Laurent, *Principes de droit civil français*, 4-ème edition, Paris, 1887, p. 137-138.

[7] O. Podaru, *The legal regime of selling goods limited genre*, Law Magazine no. 1/2000, p. 59.

[8] Buzau Court of Law, Civil Division, decision no. 4094/2013 (unpublished).

[9] D.-E. Sîngeorzan, *Contractual liability in civil and contractual law*, Publishing House Hamangiu, Bucharest, 2009, p. 228-229.

ISBN: 978-1-61804-255-2

Authors Index

ISBN: 978-1-61804-255-2